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SUPPLEMENTAL
ENVIRONMENTAL ASSESSMENT

for

STATE OPERATING PERMIT 00095 AND
FEDERAL PLAN OF OPERATIONS MTM-77779

LANDUSKY MINE
OPERATING AND RECLAMATION PLAN MODIFICATIONS
ACID ROCK DRAINAGE CONTROL AND REMEDIATION

PREPARED BY:

STATE OF MONTANA
DEPARTMENT OF STATE LANDS
RECLAMATION DIVISION
HARD ROCK BUREAU

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
LEWISTOWN DISTRICT OFFICE

PURSUANT TO THE NATIONAL AND
MONTANA ENVIRONMENTAL POLICY ACTS

NOVEMBER 1993

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DOCUMENT SUMMARY

Water resources monitoring reports from the Landusky Mine show the development of acid rock drainage (ARD) from several of the mine facilities (waste rock dumps and ore heap retaining dikes). The current operating and reclamation plans are not designed to address ARD concerns in detail. Modifications to these plans have been proposed by the mine operator, Zortman Mining, Inc. (ZMI) to corredt the ARD problems. ZMI proposes to change reclamation practices for the Mill Gulch waste rock dump, teh Sullivan Park leach pad dike and the Gold Bug pit. ZMI also proposes to identify and selectively handle material with a high ARD generation potential as well as to conduct long-term reclamation studies.

ZMI's proposed modifications have been reviewed by the permitting agencies, the Montana Department of State Lands (DSL) and the Bureau of Land Management (BLM). The agencies have developed an alternate modification plan which expands the ZMI proposal to address all mine facilities that could potentially generate ARD. This alternative would increase the reclamation capping thickness on all heaps and waste rock dumps, reduce the slopes to ensure stability, and move the approved Montana Gulch leach pad expansion to an existing disturbed area. This is the agencies' preferred alternative. Other alternatives considered include the no action alternative and suspension of mine operations.

The Landusky Mine is located in the Little Rocky Mountains, Phillips County, Montana. The mine consists of seven leach pads, four waste rock dumps, three open pit mining areas, a processing plant and associated infrastructure. The mine is permitted to disturb a total of 814 acres for mining and mining related activities.

The major rock types associated with the mine have varying degrees of acid generating and acid neutralizing ability depending on their origin and subsequent weathering patterns. Rock types which contain sulfide mineralization, mainly pyrite (FeS_2), oxidize over geologic time and are categorized as "oxide". Rock which has not oxidized is termed "unoxidized" or sometimes "sulfide." Other rock types in the deposit such as limestones, dolomites and shales have a natural ability to neutralize acid.

Acid rock drainage can occur when either unoxidized or partially oxidized material that contains sulfides comes in contact with oxygen and water. The reaction between oxygen, water and the sulfide mineral forms acid. This reaction is accelerated by the presence of a naturally occurring bacteria. The overall process is similar to natural weathering but occurs at a much faster rate due to the increased surface area in the rock created by mining activity. Once generated, the acidic water may come in contact with adjacent minerals that have the ability to neutralize acid. If this neutralizing ability is exceeded the resulting discharge would be acidic. ARD may contain levels of dissolved metals or other constituents that degrade water quality and are harmful to aquatic life.

Efforts to prevent ARD are aimed at preventing water and oxygen from coming in contact with potentially acid forming materials. This involves: identification of acid forming materials, selective handling of those materials to place them away from possible contact with either infiltrating surface waters or groundwaters, capping of rock piles with low permeability liners to prevent precipitation from infiltrating and limit air circulations, and diverison of runoff away from the rock disposal area.

The efforts proposed by ZMI are consistent with this approach but may not be extensive enough to ensure existing conditions are abated and future ARD development prevented. As a result there is still the potential for negative impacts to both water resources and relcamation revegetation under this alternative.

The regulatory agencies' approach is to assume that all the facilities have the potential to produce some acid until proven otherwise. As a result the reclamation cap has been enhanced to prevent infiltration of precipitation on not only the Mill Gulch and Gold Bug waste rock dumps, but on all the unreclaimed leach pads and mine pits. The result is that subsequent discharge from these facilities would be of acceptable water quality and have only a negligible impact on water resources. Surface reclamation success is likely with the lower slopes and cap of neutral material for a capillary break. This alternative also includes increased monitoring and trend analysis to detect any change in water quality that would require further remediation efforts.

Impacts from the no action alternative would result from continued mining under the approved operating and reclamation plans. These plans have already been demonstrated inadequate and intermim corrective measures have been taken. To date, impacts have not been severe; however, continued operations under existing permits would most likely result in increased degradation to water resources and partial failure of surface reclamation. Impacts from suspending current mining permits would be very similar to those that would occur under the no action alternative. There would be less overall mining but there would be inadequate material for reclamation. Continued mining is necessary to achieve an adequate source of neutral cap rock. This alternative was dropped from consideration.

Implementation of corrective measures at the Landusky Mine does not require nor depend on approval of the proposed Zortman Mine expansion.

It is the agencies' belief that implementation of the agency modified alternative would provide the most effective means for correcting existing ARD problems and for insuring longterm relamation success at the Landusky Mine.

Technical staff from the Montana Department of HEalth and Environmental Science, Water Quality Bureau and the U.S. Environmental Protection Agency have provided input in the preparation of this environmental analysis. BLM and DSL appreciate their comments.

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CHAPTER I - INTRODUCTION

A. PURPOSE AND NEED FOR ACTION

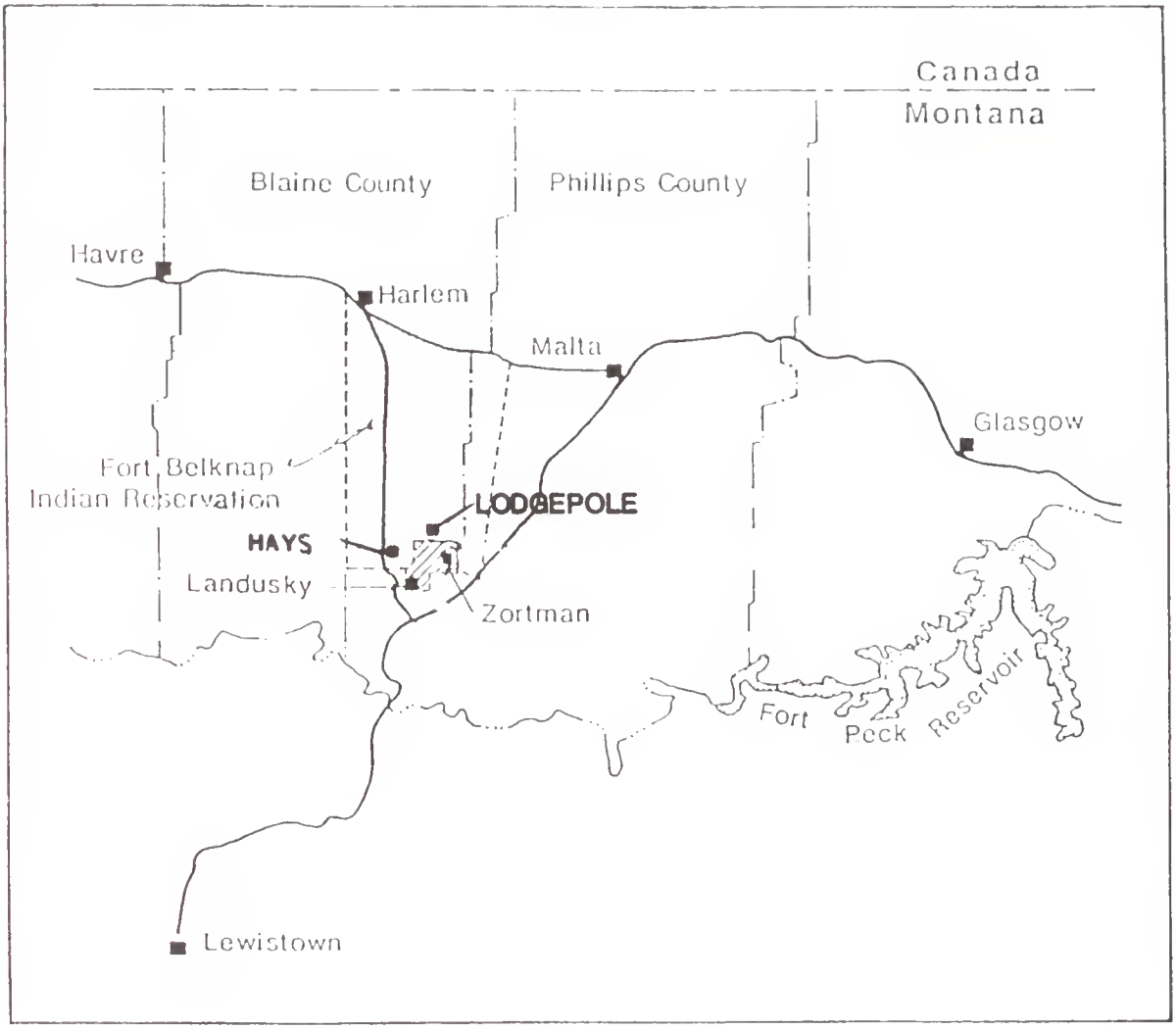
Zortman Mining Inc. (ZMI) has proposed to modify the approved operating and reclamation procedures in State Operating Permit 00095 and Federal Plan of Operations MTM-77779 for the Landusky Mine (ZMI, 1993 and ZMI letters to Montana Department of State Lands (DSL) and the Bureau of Land Management (BLM), dated November 19, 1992, February 22, March 15, April 26 and July 23, 1993). Facilities for which modified proposals have been submitted include all Landusky heap leach pads, the Gold Bug pit, Mill Gulch waste rock dump, and the Sullivan Park leach pad dike.

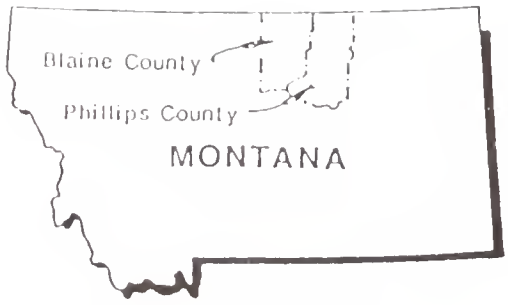
The proposed modifications have been submitted in response to the development of acid rock drainage (ARD) discharge from several of the mine facilities. Measures to prevent, control and mitigate ARD need to be incorporated into the current operating and reclamation plans in order to comply with federal and state environmental protection requirements.

B. BACKGROUND AND PROJECT LOCATION

ZMI operates the Landusky gold mine in the Little Rocky Mountains of central Montana, Phillips County. The mine area is located east of Mission Peak and north of the town of Landusky, 45 miles south of Malta, 5 miles southeast of Hays, and 8 miles southwest of Lodgepole (Figure 1). ZMI's state Operating Permit 00095 was originally issued June 6, 1979, in accordance with the Montana Metal Mine Reclamation Act (MMRA). That permit application (ZMI, 1978) was evaluated in an Environmental Impact Statement (EIS) prepared by the Montana Department of State Lands (MDSL) in 1979 (MDSL, 1979). When the BLM Surface Management regulations (43 CFR 3809) went into effect in 1981, the existing operating permit was accepted by BLM as an approved plan of operations. Subsequent revisions to the operating and/or reclamation plans have been analyzed pursuant to the Montana National Environmental Policy Acts (MEPA and NEPA) in MDSL et al 1986, 1988, 1990a, 1990b, and 1991.

The Landusky mining operation (Figure 2) is located on 1,287 acres of land of which 382 acres are patented mining claims. The remaining acreage is unpatented lands controlled by ZMI and administered by the BLM. A total of 814 acres are currently permitted for disturbance. The mine area currently contains 764 acres of disturbed land. Approximately 98 acres have been partially revegetated. The mine pits are primarily located on patented claims controlled by ZMI, while heaps, waste rock dumps and other facilities are primarily located on unpatented claims where the BLM manages the surface.





NORTH

Figure 1

General Project Location Map

FIGURE 1.

Surrounding BLM lands are managed for wildlife habitat and recreational uses (BLM, 1992). The mine area, in sections 15 and 22 of T25N, R24E, is also near the Fort Belknap Indian Reservation. At its closest, Mission Peak, the reservation is 725 feet from the mine property. The boundary is approximately 1,250 feet from the nearest mine-related disturbance, the Montana Gulch waste rock dump.

At Landusky, ore is mined from open pits, and is placed on a composite plastic polyvinyl chloride (PVC) and clay-lined heap leach pad to extract the gold from the ore. In heap-leaching, gold ore is sprinkled with a weak cyanide solution which dissolves the precious metals. The solution percolates through the ore and is collected by the liner. The collected process solution is piped to a plant where the gold is recovered, and the solution is adjusted for cyanide concentration and pH, and recycled back to the heap. Heap leaching uses cyanide to extract gold from the ore in a "closed circuit" where solution is recycled and used many times over.

Under the existing approvals 120 million tons of ore have been permitted for heap leaching at the Landusky mine. The majority of ore is contained, or being loaded, on the Mill Gulch and the Sullivan Park leach pads.

At the Landusky mine the oxidation of iron disulfides found in waste rock has produced acidity and associated metals mobility in effluent from the various mine facilities (Hydrometrics, 1992). A previous environmental review (MDSL et al, 1990b) had concluded that the acid producing potential of some rock types mined at the Landusky operation would be buffered by the neutralizing capacity of other rock types which occur within the deposits. Water resource monitoring required as a part of mine operation has provided data which documents that this has not occurred to the degree anticipated and ARD has resulted (see Chapter III).

Based on field inspections in 1992 and review of water quality monitoring data gathered from 1988 to date, the Bureau of Land Management and the Montana Department of State Lands determined in December 1992, that ZMI's approved operating and reclamation plans were not preventing ARD. Inspections showed that modifications to the plan were necessary. The proposed modifications analyzed in this document are in response to agency requirements sent to ZMI November 5, 1992 (BLM), and January 15, 1993 (DSL and BLM), and in response to a decision of the BLM State Director dated April 13, 1993.

ZMI's preliminary proposed corrective actions were submitted on November 19, 1992, February 22, and March 15, 1993. The agencies reviewed the proposals and requested further details and specific changes including revised capping scenarios for various facilities. On July 23, 1993 the final proposal (ZMI, 1993a) was submitted to the agencies.

Contingency ponds and pumpback systems are in place and functioning below problem leach pad underdrains and waste rock dumps. Recently, several large precipitation events have

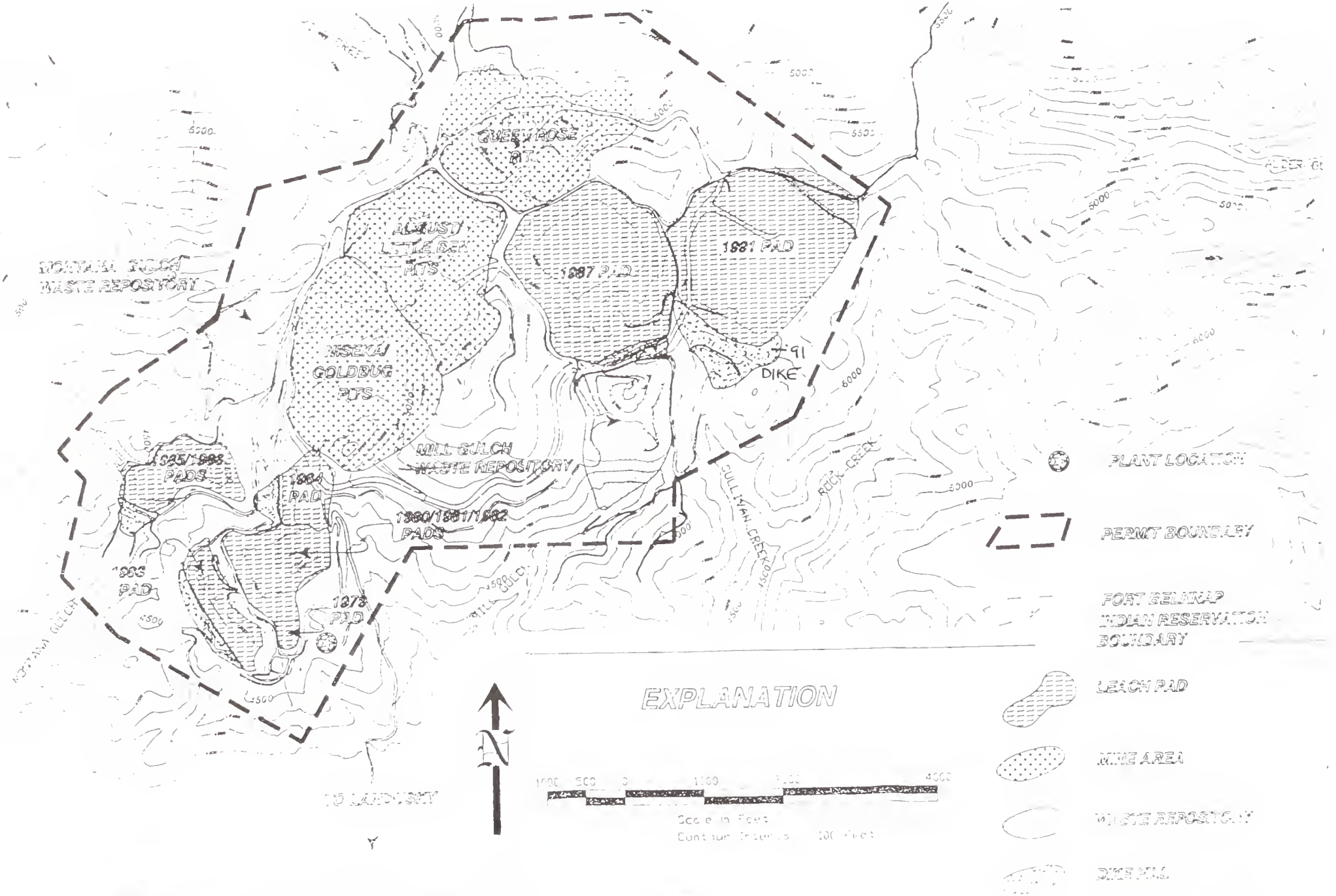


FIGURE 2. LANDUSKY MINE AREA

occurred in the Little Rocky Mountains which resulted in high flows in all drainages. Because of these precipitation events, pumpback systems at the Landusky mine were not able to capture all discharge of acidic water downgradient of certain facilities. Captured discharges were routed back to the process circuit. These short-term measures are marginally effective and demonstrate the need for mine plan modification.

C. SCOPE OF ANALYSIS

This environmental assessment (EA) is a supplement to the EA prepared for ZMI's Application for Amendment 10 to State Operating Permit 00095 and Federal Plan of Operations MTM - 77779 (MDSL et al, 1990b, and MDSL et al, 1991). This analysis evaluates the effectiveness of various operational control measures, reclamation capping scenarios, and other ARD mitigation. Thus the analysis focuses on reclamation procedures and impacts to water resources. For more information concerning other environmental aspects of the Landusky mine the reader is referred to MDSL et al, 1990b and to MDSL et al, 1991. These documents were prepared by the Montana Department of State Lands and the U.S. Department of the Interior - Bureau of Land Management and provide the most recent assessment of environmental effects from the Landusky mine.

Amendments to the Zortman mine reclamation plan, (Operating Permit 00096 and MTM 77778) east of the Landusky mine, will be evaluated in a Zortman Mine Expansion EIS currently in progress. Issues and concerns identified by the agencies and the public prior to preparation of this document are summarized in Appendix 1.

D. AGENCY RESPONSIBILITIES

A number of agencies have participated in a joint review of this proposal. The following is a description of the cooperating agencies and each agency's responsibilities.

1. Montana Department of State Lands (MDSL)

The Commissioner of State Lands must decide whether to approve Zortman Mining Inc's proposal, to modify their proposed reclamation plan, or to deny the proposed change pursuant to the Montana Metal Mine Reclamation Act (MMRA) Title 82, Chapter 4, Part 3, MCA.

The MDSL administers the MMRA which applies to state, federal, and private lands within Montana. The purpose of the act is to provide that the usefulness, productivity, and scenic values of all lands and surface waters involved in mining and exploration receive the greatest reasonable degree of protection and reclamation to beneficial use. The act and its regulations (ARM 26.4.101 et seq.) set forth the steps to be taken in the issuance of an operating permit for and the reclamation of the applicant's proposed mine expansion. When a previously approved plan becomes impractical or impossible to implement or maintain, or when environmental problems are identified,

the MMRA also provides that the Department may require an operating or reclamation plan to be changed so that it will not conflict with existing laws (82-4-337, MCA).

MDSL's rules (ARM 26.2.601 et seq.) implementing the Montana Environmental Policy Act (MEPA) Title 75, Chapter 1, MCA, then require preparation of an environmental analysis of the actions proposed under MMRA.

The Commissioner may deny a permit modification only when it can be demonstrated that air and water statutes cannot be complied with and/or the reclamation plan as proposed is not feasible (82-4-351, MCA). A permit may also be denied if a person, or any firm or business association of which that person was a principal or controlling member has a bond forfeited (82-4-360, MCA) or for failure to reclaim an operation (82-4-341(6), MCA). ZMI has not forfeited any bonds under the MMRA and has not failed in its reclamation obligations.

The Department of State Lands also has authority to enforce the Metal Mine Reclamation Act. It may not, however, enforce statutes delegated to other agencies.

Specific to the corrective actions under evaluation in this EA and the circumstances surrounding those actions, the Department has issued a Notice of Noncompliance for failure to handle sulfide materials properly. Penalties will be assessed as soon as the Department has completed the processing of the corrective action and this MEPA/NEPA analysis.

2. United States Department of the Interior Bureau of Land Management (BLM)

The BLM is responsible for the evaluation and regulation of mineral activities on public lands. The BLM uses the 43 CFR 3809 regulations to prevent unnecessary or undue degradation of the public lands with respect to locatable mineral activities. The BLM evaluates the activity through the National Environmental Policy Act of 1969 (NEPA), and the Federal Land Policy Management Act of 1976 (FLPMA). Federal regulation 43 CFR 3809.3-1 provides for a joint federal-state regulatory program. Such a program was initiated May 9, 1984, by a Memorandum of Understanding (MOU) between the BLM and MDSL. This agreement allows for joint agency NEPA analysis.

The BLM has issued a Notice of Noncompliance for improper waste handling for Mill Gulch Waste Dump on May 27, 1993. On August 9, 1993, another Notice of Noncompliance was issued for failure to comply with other federal laws specifically the Clean Water Act.

3. Montana Department of Health and Environmental Sciences (DHES)

Water Quality Bureau (WQB)

The WQB of DHES is responsible for administration of the Montana Water Quality Act (Title 75, Chapter 5, MCA), providing for the classification of surface waters, establishing surface water quality standards, and administering permit programs to control the discharge of pollutants into state waters. This program includes delegated responsibilities from the U.S. Environmental Protection Agency (EPA) for implementation of the Federal Clean Water Act. Any water treatment needed, beyond passive measures such as constructed wetlands, would be imposed by the WQB.

A Montana Pollutant Discharge Elimination System (MPDES) permit must be obtained before any discharge to state water may occur. The MPDES permit contains water quality limitations and requires self-monitoring of effluent by the permittee. Mining operations must also comply with Montana groundwater standards.

On April 13, 1993, the DHES notified ZMI of apparent Montana Water Quality Act violations, and requested additional information to determine the extent of these apparent violations.

On August 24, 1993, DHES filed a complaint and application for injunction against ZMI. This complaint requires that ZMI take corrective actions to ensure that the mine is in compliance with the Montana Water Quality Act. The complaint also requires ZMI to obtain an MPDES permit(s) for all state waters which may be impacted by mining disturbances. ZMI's application for such permits was received on August 30, 1993 (ZMI, 1993b).

4. United States Environmental Protection Agency (EPA)

The EPA Region VIII has jurisdiction or special expertise regarding protection of water quality pursuant to the Clean Water Act and mined-land restoration pursuant to the Solid Waste Disposal Act. The EPA Region VIII may also be designated as a cooperating agency pursuant to 40 CFR 1501.6. This code provides that the lead agency may request any other federal agency to serve as a cooperating agency, if the agency has jurisdiction or special expertise regarding an environmental issue or issues that should be addressed in a NEPA document. The EPA has both jurisdiction and expertise.

On April 22, 1993, the EPA issued a letter to ZMI requesting more information on facilities siting, topography, and drainages pursuant to Section 308 (33 U.S.C. 1318) of the Clean Water Act. The EPA has inspected the site numerous times and is currently coordinating with the DHES-WQB to assure compliance with the Clean Water Act. On July 28, 1993, the EPA issued a notice of violation to ZMI for discharge without a permit (per Section 301(a) (33 U.S.C. 1251 et. seq.) Clean Water Act). The EPA has delegated authority to issue National Pollutant Discharge Elimination System (NPDES) permits in Montana to the Montana DHES. The EPA and DHES are taking joint actions to ensure compliance with the Clean Water Act and Montana Water Quality Act.

E. THE PERMITTING PROCESS

The permitting process usually begins with an applicant's submission of a plan of operations to the appropriate State and Federal agencies. In this case, the process began when the BLM and the MDSL identified a need for a corrective action or change in the reclamation plan in December 1992. The agencies received ZMI's proposal (ZMI, 1993a, etc.) to amend their operating and reclamation plans to incorporate segregation of potentially acid generating material, as requested by the MDSL and the BLM. Subsequently the plan must be evaluated pursuant to MEPA and NEPA.

The NEPA and the MEPA are Federal and State laws which direct the BLM, the MDSL and DHES to evaluate and disclose effects of proposed activities on Federal and State lands to the public and to officials making decisions concerning the proposal. Under the NEPA and MEPA, issues and alternatives are developed based on both public and agency input gathered during scoping. These issues are then tracked through the environmental analysis phase of the document. See also, Appendix 1.

The deciding officials review the alternatives, weigh the possibilities for positive and negative impacts, and reach a decision. A decision document is then prepared which outlines the major points of the decision and the rationale used to reach the decision. The activities outlined in the decision document are then approved to be implemented on the ground. State decisions can be challenged in district court and BLM decisions are appeable to the Interior Board of Land Appeals (IBLA).

This chapter identifies ZMI's proposed plans and identifies other alternatives to be considered in decision making.

A. ZMI PROPOSED MODIFICATIONS

This section describes ZMI's proposed modifications to the approved mining and reclamation plans. ZMI has proposed these modifications to address the potentially acid-generating character of some mined ore and waste rock. The modifications described below are contained in documents (ZMI, 1993a) and letters submitted to the MDSL and BLM dated November 19, 1992, February 22, March 15, April 26 and July 23, 1993.

The facilities and supporting roads addressed by ZMI's initial proposal (Figure 2) are located in three drainages: Montana Gulch, Mill Gulch and Sullivan Creek. Table 1 summarizes the approved reclamation plan and the proposed changes for the facilities which exist in each drainage. Mill Gulch and Sullivan Creek drainages are upgradient of the small town of Landusky. The Montana Gulch drainage enters Rock Creek downgradient of Landusky. All three drainages report to the Rock Creek drainage which eventually discharges to the Missouri River.

All Landusky Heap Leach Pads

The proposed reclamation plan would delay perforation of the liner systems beneath the heaped ore until ZMI provided the agencies with 90-days notice of its intent to puncture the liner.

Mill Gulch Waste Rock Dump

Placement of waste rock has not been authorized on the Mill Gulch dump since February 1993. The existing dump (Figure 3) would be reclaimed as follows. A 6-to 12-inch clay liner on the top of the dump would be covered by a 15 mil synthetic PVC liner. On top of the PVC liner a protective geofabric layer would be placed to prevent puncture of the PVC liner. A 20 mil PVC liner would be used in critical drainage areas. Three feet of non-acid generating waste would be placed above this liner to serve as a capillary break (to prevent penetration of roots into the synthetic liner). The dump top would then be covered with 12 to 18 inches of soil. Runoff from precipitation which falls on the dump face would be routed into clay and PVC lined, rip-rapped side ditches along the dump perimeter via similarly designed drains constructed on 15 to 30 foot wide benches which would transect the dump face every 100 feet of vertical slope length. Drainage from the backsloped dump top would be routed into the main Landusky drainage system rather than the side ditches, to reduce the flow in these steeper side ditches. The overall slope of the dump face and benches would be 2.5 horizontal to 1 vertical (2.5:1).

Table 1: Summary of Approved and Proposed Reclamation Plans for the Existing Landusky Facilities by Drainage

DRAINAGE	FACILITIES	SUMMARY OF PROPOSED RECLAMATION PLAN	SUMMARY OF APPROVED RECLAMATION PLAN	WATER QUALITY STANDARD CLASSIFICATION
Montana Gulch	'83, '84, and '85/'86 Leach Pads	same as approved plan except to delay liner perforation until agencies have received 90 days notice	rinse to <0.22 WAD CN', reduce slopes to 2H:1V, cap with 8-12" soil, revegetate, perforate liner	C-3
Montana Gulch above '86-'86 Leach Pad	Montana Gulch Waste Dump	no change (this has already been implemented)	reduce to 2H:1V slope, cap with 8-12" soil, revegetate	C-3
Montana Gulch east upper reach	Gold Bug Pit/ Waste Dump	continue waste disposal in the Gold Bug pit, salvage soil, install limestone/lime underdrain, backfill in 5' lifts with 11 million tons of segregated waste rock to the 4900' level, high sulfur material isolated in the interior, at 4740' level a 6" compacted clay barrier to separate the upper dump from the lower dump, 25' wide clay and synthetic lined benches with lined ditches every 100 vertical feet, lined side ditches, dump top would be covered with 6" of clay or >10 mil synthetic liner to form an impermeable cap, dump slopes would be covered with 6" of compacted clay and 12-18" of non-acid generating waste rock for use as a capillary break, at final reclamation 30-40 percent of the slopes would be covered by non-acid generating waste scree and 60-70 percent would be 12 -18" of soil; at 4900' level decision to backfill with additional waste would be made; the final overall slope would be 2.25:1	cover with 8-12" soil on benches, vegetate with grasses and trees	C-3

DRAINAGE	FACILITIES	SUMMARY OF PROPOSED RECLAMATION PLAN	SUMMARY OF APPROVED RECLAMATION PLAN	WATER QUALITY STANDARD CLASSIFICATION
Montana Gulch and Mill Gulch above the waste dump	'79,'80-'81-'82, and '87 Leach Pads	same as approved plan except to delay liner perforation until agencies have received 90 days notice	rinse to <0.22 WAD CN*, reduce slope to 2:1, cover with 8-12" soil, revegetate, perforate liner	C-3
Mill Gulch below the '87 Heap Leach Pad	Mill Gulch Waste Dump	discontinue waste disposal in Mill Gulch, reduce overall slope to 2.5:1, every 100 vertical feet install 15-30' wide clay lined benches with synthetic lined ditches, synthetic lined sideline ditches, cover the entire dump slope with 6" clay cap overlain by 12-18" non-acid generating waste scree, cover 60-70 percent of the surface area with 12-18" soil and revegetated, 30-40 percent remains rock scree; cap dump top by first backsloping with 36-84" neutral waste followed by a 6" clay/15 mil PVC liner/geofabrick, cover with 36" non-acid generating waste capillary break with 12-18" soil, install instrumentation to evaluate infiltration and chemical reactions.	reduce slopes to 2:1 with 25' benches every 200' of slope length (for diversionsl, cover with 8-12" soil, revegetate	C-3
Sullivan Creek above dike	'91 (Sullivan Park) Heap Leach Pads	same as approved plan except to delay liner perforation until agencies have received 90 days notice.	rinse to <0.22 WAD CN*, reduce slopes to 3:1, cover with 8-12" soil, revegetate, perforate liner	C-3
Sullivan Creek below the '91 Leach Pad	Sullivan Park Dike/'91 Leach Pad Contingency Pond	salvage soil, reduce to average 2.5:1 slope, cover entire surface with 6" compacted clay cap overlain by 12-18" non-acid generating waste scree, cover 60-70 percent of surface area with 12-18" soil and revegetate, 30-40 percent remains rock scree, install diversion benches every 100 vertical feet	reduce to 2:1 slope, cover with 8-12" soil, revegetate	C-3

* <0.22 WAD CN = less than 0.22 parts per million weak acid dissociable cyanide.

In order to spread and compact clay on the dump slopes, the slope must be reduced to a more gradual slope than the currently permitted 2 horizontal to 1 vertical (2:1). ZMI proposes to reduce the slopes of this facility to an overall 2.5:1. The actual slopes would vary from 2.5:1 to 2.75:1, in the upper region of the dump to more steep, and from 2.25:1 to 2.5:1 in the lower region. All dump slopes would be covered by 6 inches of clay. Subsequently a 12 to 18 inch layer of non-acid generating waste would be added. Finally, 12 to 18 inches of soil will be placed on 60 to 70 percent of the slope surface. If the reclamation surface performance study (ZMI, 1993a) indicates that a different capping sequence would be more effective, the capping sequence would be modified for reclamation of this and other facilities determined to have the potential to produce ARD.

All Landusky Pits

ZMI has not proposed any changes to the pit reclamation plans other than for the Gold Bug pit.

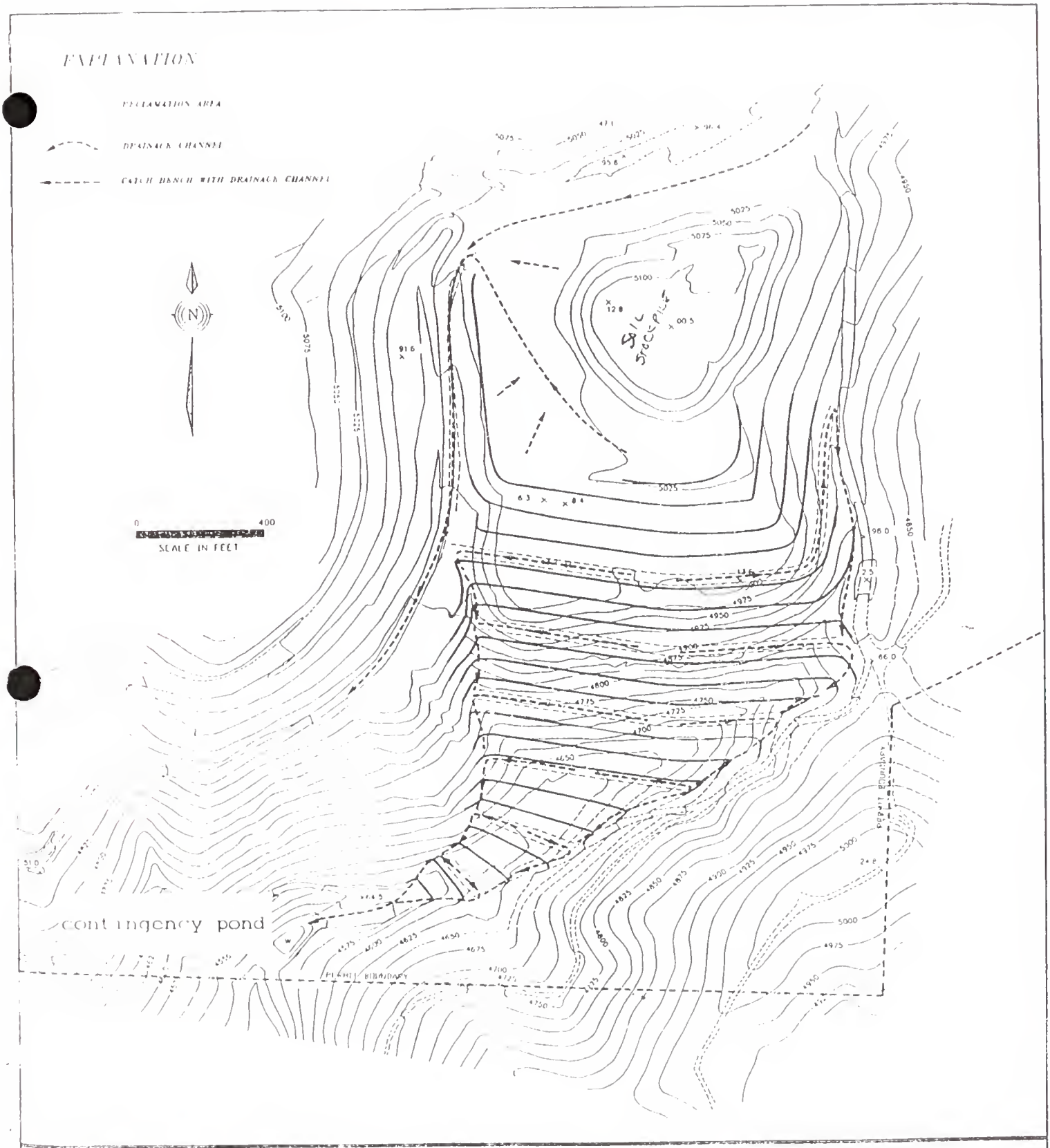
Gold Bug Pit/Waste Dump

Waste rock which was to report to the Mill Gulch waste rock dump has been placed in the Gold Bug pit (BLM, April 13, 1993). Dump construction in the pit is proposed to progress in 25-foot lifts until the entire pit has been backfilled to the 4900 foot level as depicted in Figure 4 for a total of 11 million tons of waste. The pit has the capacity to hold 50 million tons of waste rock if completely backfilled to the 5325 foot elevation. However, ZMI has neither proposed nor been approved to mine enough material to backfill the pit above the 4900 foot elevation. ZMI would construct the dump with an overall slope of 2.25:1. Waste in the dump would be segregated based upon total sulfur content, so that reactive waste would be isolated in the interior of the facility.

The Gold Bug waste dump would be reclaimed similar to the Mill Gulch waste dump, except that the waste dump would be capped and revegetated concurrently with dump construction. Rather than covering the entire reclaimed top with soil, ZMI proposes to reclaim to a 60 to 70 percent vegetation and 30 to 40 percent rock scree mosaic pattern (Figure 5), similar to that which naturally occurs on many hillsides within the Little Rocky Mountains. Lined ditches would be constructed on benches across the dump every 100 vertical feet.

Sullivan Park Dike/'91 Leach Pad Contingency Pond

The retention dike which holds the Sullivan Park leach pad in place was partially constructed with acid generating waste rock. The slope of this structure is 2:1 and would have to be reduced to 2.5:1 to facilitate the placement of a clay infiltration barrier on the dike slopes.



MILL GULCH RECLAMATION AND DRAINAGE

ZORTMAN MINING INC.

DRAWN BY: Melissa J. Hall 6/21/93

FIGURE 3.

EXPLANATION

BLUE WASTE REPOSITORY

STAGE 2
4900 ELEVATION

DRAINAGE DITCH

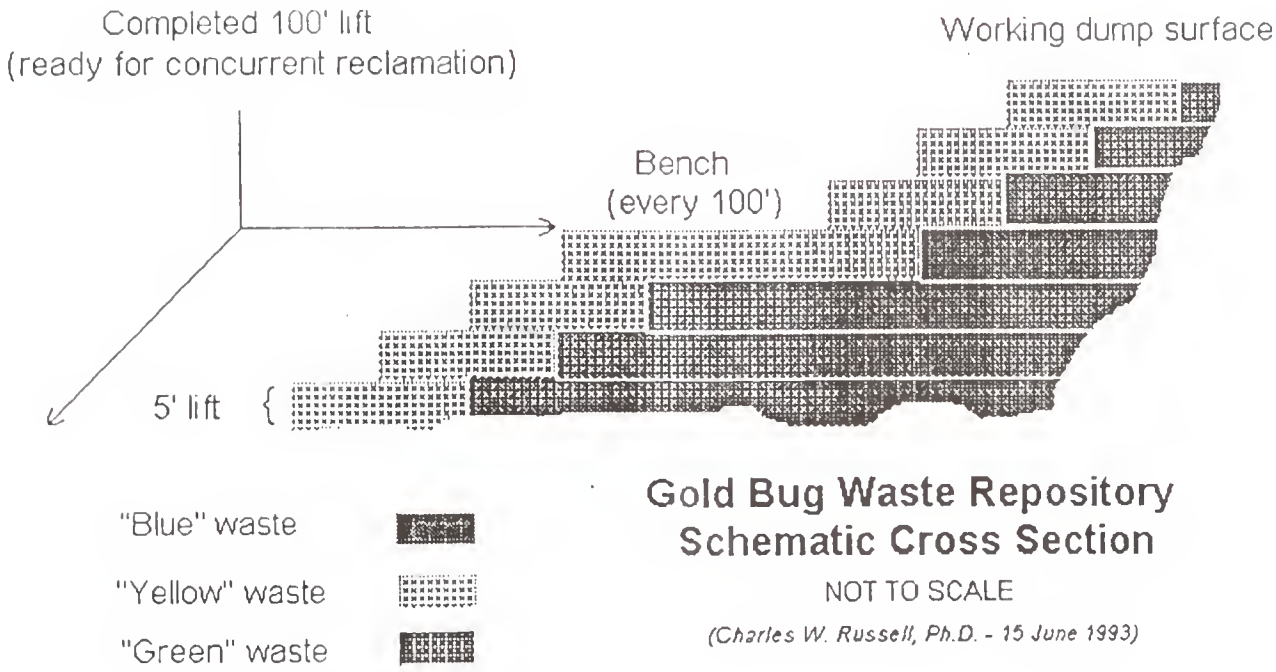
FIGURE 4.

400 800
scale in feet

GOLD BUG WASTE REPOSITORY
PLAN VIEW OF 4900 ELEVATION

ZORTMAN MINING INC.
DRAWN BY: Michael J Hall 06/15/93

MATERIALS PLACEMENT



INFILTRATION CONTROLS

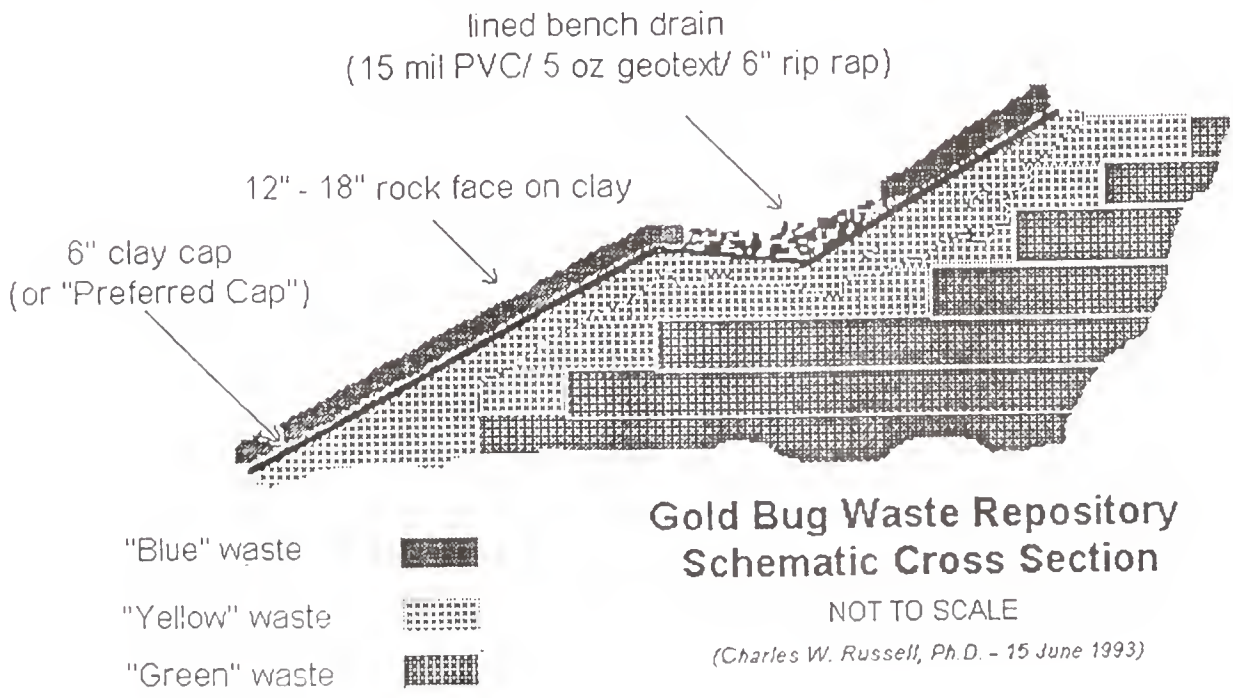

lined bench drain
(15 mil PVC/ 5 oz geotext/ 6" rip rap)
12" - 18" rock face on clay
6" clay cap
(or "Preferred Cap")
"Blue" waste
"Yellow" waste
"Green" waste
Gold Bug Waste Repository
Schematic Cross Section
NOT TO SCALE
(Charles W. Russell, Ph.D. - 15 June 1993)

FIGURE 5.

However, the dike supports the leach pad and its slope cannot be simply reduced to facilitate capping. Therefore, additional material, approximately 0.3 million tons of less than 0.5 percent total sulfur waste rock would be placed on the existing dike slope to produce the desired slope of 2.5:1. After resalvaging of soil material, this additional material would fill in an area of previous disturbance, including a portion of the existing contingency pond below the dike (reducing its capacity by approximately 350,000 gallons).

To reduce infiltration, ZMI proposes to cap the dike with a 6-inch layer of compacted clay. A 12- to 18-inch layer of neutral/non-acid generating waste would be placed over this clay cap. Finally, 60 to 70 percent of the non-acid generating waste would be covered with 12 to 18 inches of soil and revegetated.

To limit runoff velocities, to facilitate drainage off of the main dike face, and to protect soils from erosion, benches would be placed every 100 vertical feet. Benches would be from 15 to 30 feet wide, and sloped back into the dike with grades of 5 to 10 percent (Figure 6). These benches would be capped with clay and a synthetic liner and would serve as access roads to maintain a 10- to 20-foot wide drainage ditch. This drainage ditch would be lined with a synthetic impermeable liner, which would be held in place with neutral rocks greater than 6 inches in size.

Side ditches would be installed to collect the runoff from the top and slopes of the reclaimed dike. The liner for these ditches would be a synthetic impermeable barrier which is bedded upon 6 inches of clay to gravel-sized material (Figure 7). The liner would be secured in place with 6 to 18 inches of sized neutral material. Drainage from the upper portion of the dike would be diverted into the drains on the dike east and west flanks. A plan view of the reconfigured Sullivan Park dike is shown in Figure 8.

Mine Products Characterization Program

Effective implementation of the reclamation plan requires that certain mine facilities be geochemically characterized, resloped, and capped to allow identification and isolation of this reactive waste and to decrease water infiltration into the waste rock dumps. Due to the manifestation of acid rock drainage (ARD) associated with various waste rock piles, and at the request of the BLM and the MDSL, ZMI has completed the preliminary phase of a mine products characterization program (ZMI, 1993a and ZMI letter dated July 30, 1993). This has allowed the company to reach a preliminary determination that a relationship exists between the rock's total sulfur content and its net neutralizing potential (NNP). The mine products characterization program directs the segregation and isolation of waste in the Gold Bug pit/waste rock dump and provides for sampling and geochemical testing of all unreclaimed heap leach pads.

Cross-Section
of Bench Drain Ditches

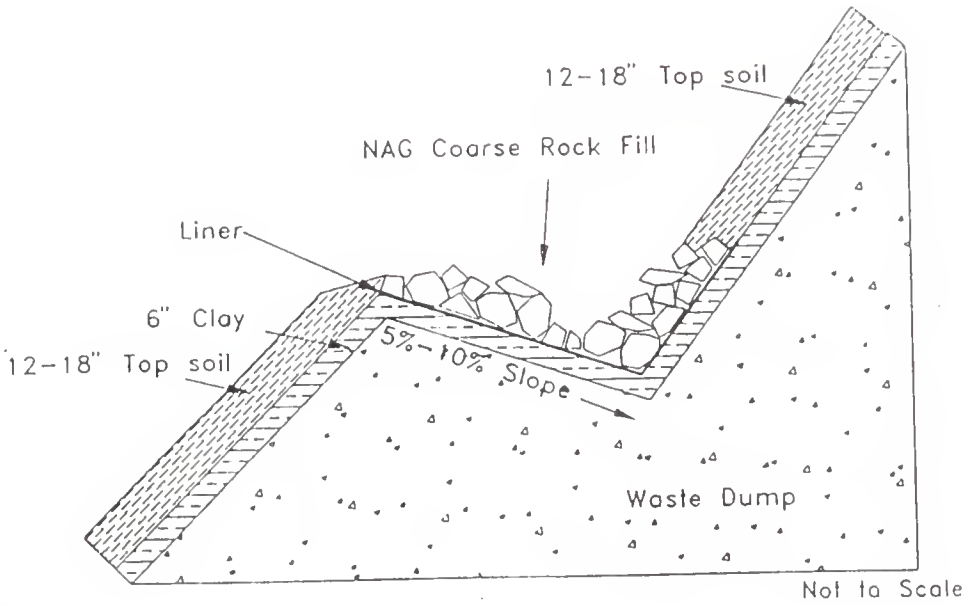


FIGURE 6.

Cross-Section
of Side Drain Ditches

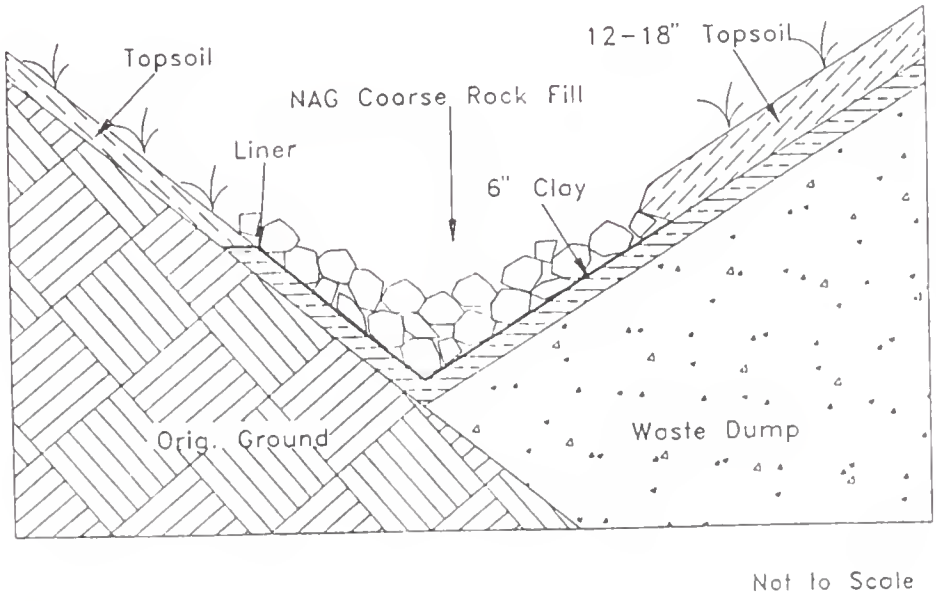


FIGURE 7.

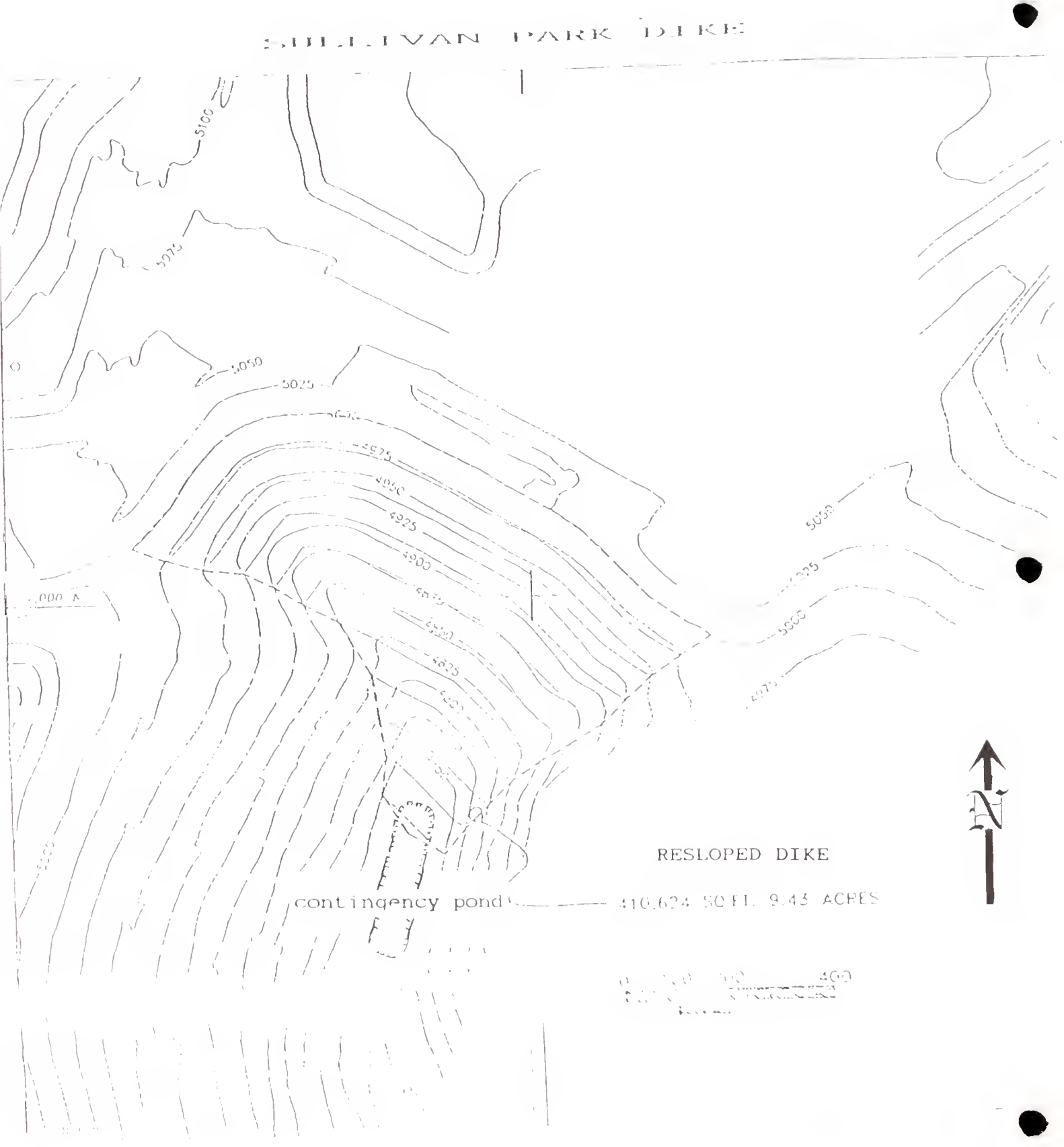

SULLIVAN PARK DIKE
5100
5075
5050
5025
4975
4950
4925
4900
5050
5025
5000
RESLOPED DIKE
contingency pond
410,624 SQ FT. 9.43 ACRES
400

FIGURE 8.

For the Landusky ore and waste rock, ZMI has determined a correlation exists between the total sulfur content of the rock and the NNP, which was evaluated by the Sobek method (Sobek et al, 1978) as modified by Schafer and Associates (ZMI, 1993a- Table 2, Figures F-1 and F-2). Seven hundred and forty one blasthole samples from the Little Ben/August and Queen Rose pits have been analyzed for NNP and total sulfur. Based upon these data, waste categories have been defined for material which has low risk for acid production (0 to 0.2 percent total sulfur), material which has moderate risk for acid production (0.2 to 0.5 percent total sulfur), and those which are expected to be acid generating (> 0.5 percent total sulfur). These materials are delineated with color-coded flagging at the excavation site to assist in the isolation of reactive rock and stockpiling of nonreactive capping material. Also, the loaders are fitted with colored lights to signal to the haul truck drivers where to deliver their loads of waste rock.

Table 2: Characterization Of Waste Based On Total Sulfur And NNP Analyses Of 741 Samples

Category	Blue waste	Yellow waste	Green waste
Total sulfur (%)	0.0 - 0.2	0.2 - 0.5	greater than 0.5
Average sulfur (%)	0.10	0.32	0.78
Average NNP	22.30	1.11	-20.95
Number of samples	345	227	169
Placement in Facilities	reclaimed exterior	between interior and exterior	interior

ZMI is analyzing a composite of every third to fifth blasthole for total sulfur content. After blasting, ore grade material is marked with red flagging and trucked to the leach pad. Waste of greater than 0.5 percent total sulfur content has been determined to be potentially acid generating. This material is marked with green flagging, and is placed in an isolated location in the center of the Gold Bug waste dump. Waste rock having a total sulfur content between 0.2 percent and 0.5 percent is flagged yellow, and is used for construction of the waste rock dump around the green waste. Waste having less than 0.2 percent total sulfur is marked with blue flagging and stockpiled for capping and construction material (ZMI, 1993a. Table 3).

The sulfur values of the blasthole samples are plotted on the same map as the gold assays when ore and waste blocks are discriminated (ZMI, 1993a-Figure F3). All ore, regardless of total sulfur content is taken to the '91 heap leach pad. The remaining waste is assigned to blocks

which are classified on the basis of the most restrictive waste category which is included in any given block (i.e. if a block of predominantly "yellow" waste contains some "green" class waste, the entire block would be handled as "green" waste (Table 3). The following waste classification procedures are used.

To ensure the validity of these classification schemes, every year 300 to 500 check samples would be analyzed for total sulfur and NNP. For already existing, still unreclaimed facilities, such as all the heap leach pads, total sulfur determinations are proposed to be made from surface samples collected on a surveyed 100 foot grid. Results would be reported to the agencies on topographic maps and contoured according to the color-code given in Table 3.

Table 3: Mine Products Characterization Program

Mined Material	Color of Flagging	Location of Placement
ore	red	heap leach pads
waste - greater than 0.5 per cent total sulfur content	green	isolate in center of waste rock dump
waste - greater than 0.2 percent but less than 0.5 per cent total sulfur content	yellow	layer over green waste isolated in center of waste rock dump
waste - less than 0.2 percent total sulfur content	blue	used for unrestricted construction and for reclamation and capping over yellow waste

Water Monitoring Plans

Two water monitoring programs are in place at Landusky: an operational plan and a general plan. ZMI has expanded their operational water resources monitoring plan (ZMI 1993b) to include additional monitoring sites and to monitor for additional parameters. New surface water locations are now being monitored, sumps of reclaimed leach pads are being monitored, and ZMI's laboratory is developing the ability to analyze water samples for metals and sulfate. ZMI has not proposed any modifications to the general water resources monitoring plan (Hydrometrics, 1993a).

B. AGENCY MODIFIED ALTERNATIVE

This alternative is the same as the ZMI proposed action with additional operating, reclamation and monitoring measures imposed by the MDSL and BLM. The mitigating measures described below have been developed by the agencies in order to further reduce impacts and prevent unnecessary or undue degradation. If this alternative was selected these measures would become stipulated conditions of approval.

ZMI's proposals to date have focused on the Mill Gulch waste rock dump and the Gold Bug pit. Other facilities would require revised reclamation procedures. The agencies have developed conceptual plans for the leach pads, waste dumps, dikes and pits, for this EA. Prior to final reclamation, some adjustments in these plans would be necessary.

All Landusky Pits

ZMI would map all pits using visual analysis of sulfide percentages (especially the iron uslifdes), oxidation, and particle size distribution and using analytical measurements of paste PH and total sulfur, to identify areas of potential acid production. As final benches are mined, surfaces would be tested for acid generating potential. Areas with the potential to acidify runoff would be capped with 6 inches of compacted clay prior to reclamation. Depending upon final pit configurations and locations of sulfide zones, and other factors, final pit reclamation would include partial backfilling with waste and/or spent ore to bury exposed sulfides and to cause reclaimed pits to be free-draining rather than draining internally. After pit backfilling, a channel would be constructed to route pit runoff from all pit areas ultimately to Montana Gulch. The surface of this backfilled material would require capping to minimize infiltration prior to soil replacement and revegetation. Sources of backfill would include waste from further mining, from the Gold Bug waste rock dump, or from neutral spent ore from the Mill Gulch leach pad.

Testing of pit highwalls and benches above the backfilled zone for acid generating potential would be required. Testing would include total sulfur analyses, static and leachate extraction tests, and in-place testing of highwall material. If it is not feasible to bury and cap all acid generating portions of the pit walls, then reclamation must provide for neutralization of acidic runoff from the highwalls and diversion of runoff around acid generating areas. Where possible, diversions above pits would prevent storm water run-on. Construction of diversions lined with limestone or other neutralizing material below highwalls and construction of wetland areas to remove dissolved metals from runoff, or alternate reclamation designs of equal or greater effectiveness, would be required.

All Landusky Heap Leach Pads and Waste Disposal Facilities

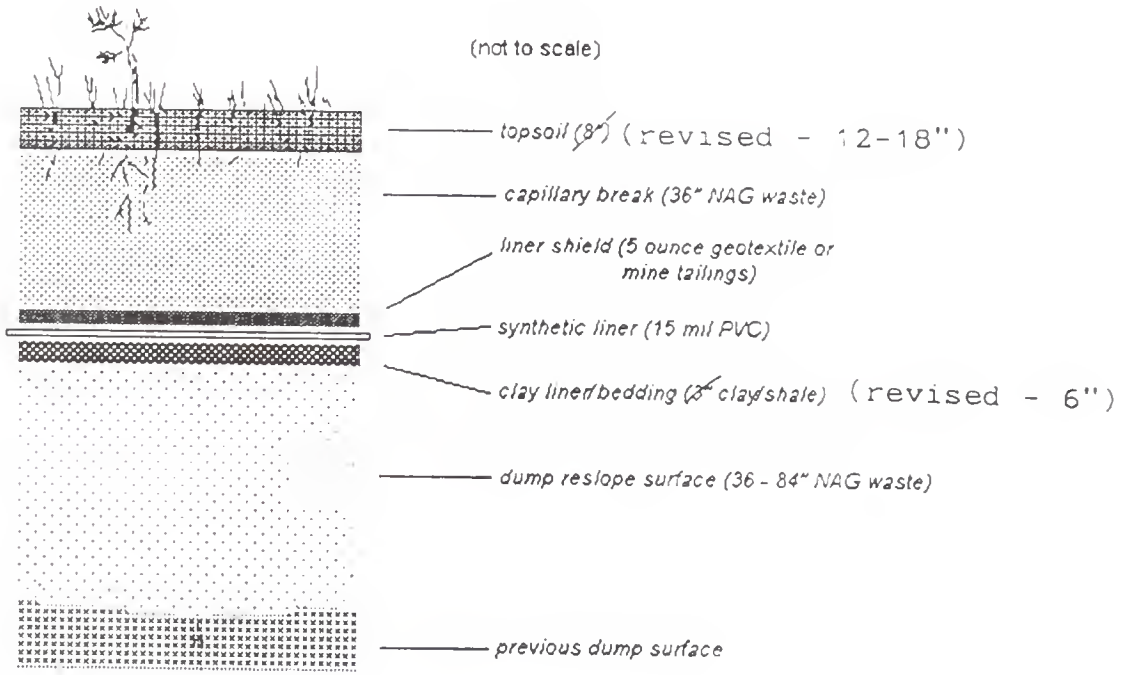
Unless the rock within a facility is demonstrated to the agneicies' satisfaction to not be acid generating, ZMI would be required to reslope all facilities to an overall 3:1 slope or flatter where topographic considerations allow or as determined technically feasible by the agencies. After slope reduction, ZMI would be required to conduct grid sampling, on 100-foot centers, of surficial material for total sulfur content. ZMI would be required to place at least 36 inches of < 0.5 percent total sulfur ("yellow waste") rock over any areas which contain exposed material of greater sulfur content. On top of this surface, a 12-inch clay layer would be compacted in two lifts. ZMI would be required to place 15 mil synthetic liners on crest surfaces flatter than 5 percent grade. A liner shield, such as geofabric or screened tailing material, would be placed over the synthetic liner to prevent perforation. A capillary break using non-acid-generating waste would be installed above the synthetic and/or clay liner. This capillary break would be 36 inches on the dump tops and at least 18 inches on the side slopes. Finally, 12 to 18 inches of soil would be placed above the capillary break (Figure 9). No rock scree would be allowed.

The non-acid generating capillary break to be installed in the capping sequence above the compacted clay liner would be constructed with material having the following characteristics: 1) a neutralization potential 3 times greater than the acidification potential (NP>3AP), and 2) a net neutralization potential greater than +20. Not all "blue waste" would meet this criteria. Segregation of material suitable for the capillary break portion of the reclamation cap would be made based primarily on lithologic unit character and total sulfur content. This would necessitate segregation and stockpiling during mining of rock units such as bighorn dolomite, Emerson shale, etc. from the color-coded blue, yellow, or green waste rock. Blue waste may be used to meet the performance objective of a non-acid generating cap, but only after results from long-term leachate extraction testing in the field have demonstrated, to the satisfaction of the agencies, its non-acid generating character.

ZMI would be required to sample the water which collects in the sumps within reclaimed leach pads, and to measure phreatic surface elevations within each leach pad. From the rate of phreatic surface rise, the rate of infiltration into a reclaimed leach pad would be estimated. If the rate of water infiltration and accumulation within each pad is kept sufficiently low for 10 years such that no degradation would occur, liner perforation could be allowed. If water quality or quantity problems are identified through monitoring, water recovery systems would be required. If water levels within the leach pads would reach such drains the water would flow out of the leach pads.

FIGURE 9. CAPPING SEQUENCE

CAPPING SEQUENCE


(not to scale)
topsoil (8") (revised - 12-18")
capillary break (36" NAG waste)
liner shield (5 ounce geotextile or mine tailings)
synthetic liner (15 mil PVC)
clay liner/bedding (3' clay/shale) (revised - 6")
dump reslope surface (36 - 84" NAG waste)
previous dump surface

Montana Gulch Leach Pad Expansion

ZMI would be requred to not proceed with the approved expansion plans for the Montana Gulch leach pad. Instead, ZMI would be allowed to utilize areas in and adjacent to the current Sullivan Park and Mill Gulch leach pads for placement of the ore that would have gone on the Montana Gulch leach pad expansion. The rationale for this mitigating measure is to reduce further disturbance in the Montana Gulch drainage, to place material with acid generating potential away from surface waters, and to utilize the mined ore to fill in low areas to facilitate reclamation.

Sullivan Park Dike/'91 Leach Pad Contingency Pond

Resloping of the Sullivan Park dike would decrease the capacity of the contingency pond located below it. Thus, construction of additional ponds would be required to return the capacity to the permitted 1,300,000 gallon capacity (ZMI, 1989; MDSL and BLM, 1990b) or to an approved design storm event if appropriate.

Mine Products Characterization Program

In ZMI's mine product characterization program, a static, modified acid-base accounting (ABA) method (Sobek et al, 1978) was used, as modified by Schafer and Associates, to determine the net neutralizing potential (NNP) of the rock material to be mined. This method assumes that all neutralizing minerals will be available for reaction. For the experimental procedure, this is true because the sample is ground to a very fine grain size and more surface area is exposed. However, when applying this analytical method to determine the potential for acid production for waste rock or spent ore, the assumption is not always valid because the true availability of the neutralizing minerals can be much less.

Because of the variability in interpreting results derived using a static method, ZMI would conduct long-term leachate extraction testing in the field to validate the 0.2 percent total sulfur cutoff used for waste segregation. Also, when "blue" waste is being characterized ZMI, would sample and test every blasthole for total sulfur. If any sampled blasthole has a total sulfur value of greater than 0.2 percent the waste would be classified as reactive "yellow or green" waste (ZMI, 1993a; Chapter II, ZMI Proposed Modification, Mine Products Characterization Program).

Mine Facilities' Monitoring

ZMI has reclaimed almost 43 acres of other mine waste dumps and heap leach pads. For these reclaimed facilities, ZMI would be required to characterize the surface material on a 100-foot grid as was proposed for the unreclaimed leach pads. Based on the sampling results and continued water monitoring results, the agencies would decide if the reclamation must be redone.

For unreclaimed facilities, ZMI would be required to conduct 2 years of monitoring using best available technologies (BAT) for instrumentation of each heap leach pad, waste rock dump, and any other structure built with potentially acid producing material to evaluate the extent of and/or potential for acid rock drainage release into existing drainages. The data collected would be used to establish baseline conditions within each facility so that future monitoring results can be accurate.

All Watershed Diversion Structures

Diversion structures for final reclamation need to be designed to withstand large storm events. The minimum size design storm that would be used at Landusky is the 6-inch, 100-year, 24-hour storm.

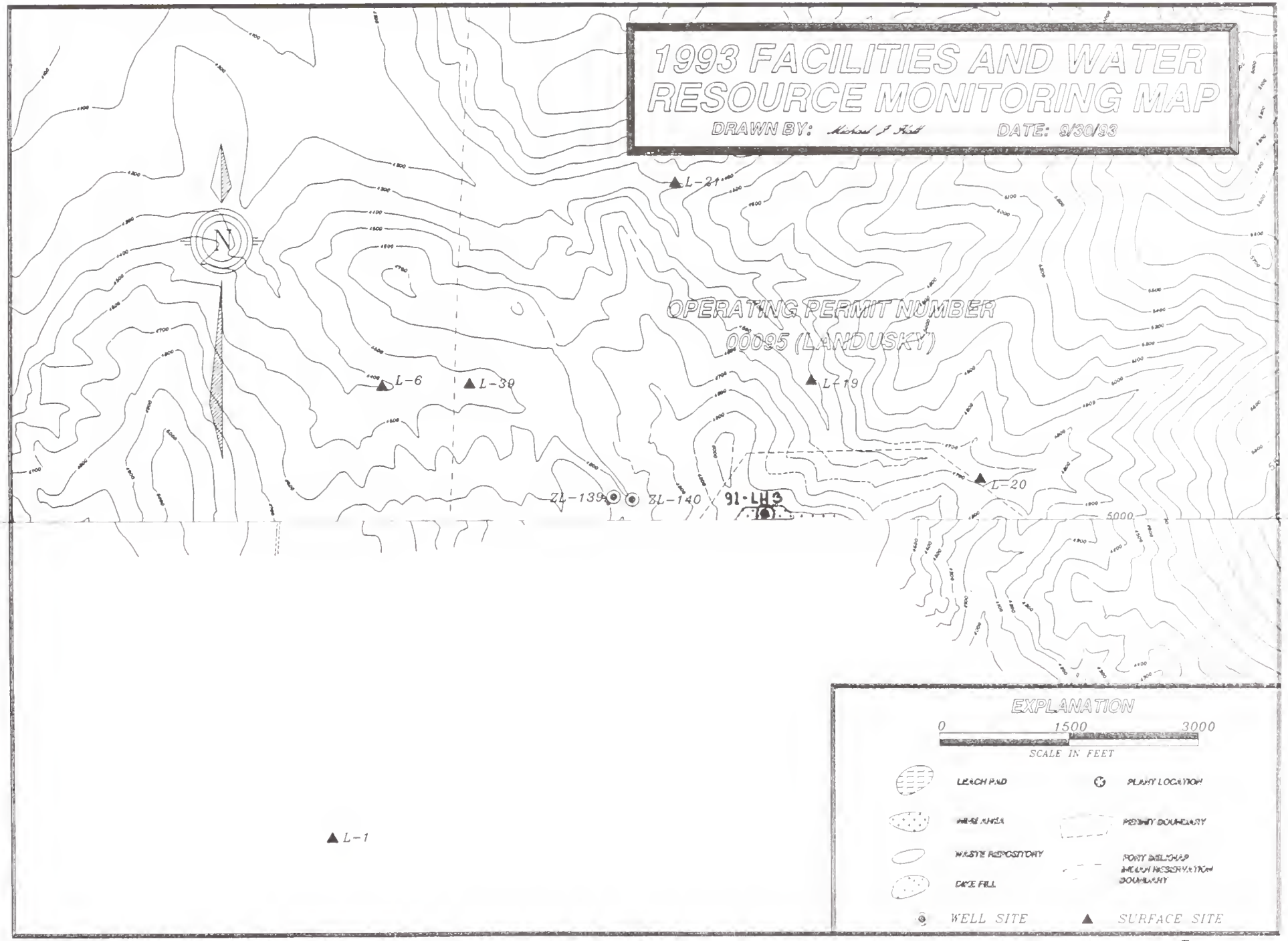
Sizing of diversions would be based upon the risk to the environment or public health, associated with failure of a particular diversion. Diversions intended to prevent erosion of, or infiltration into, facilities containing acid generating material after final reclamation must be designed to withstand a 7-inch, 24-hour storm event. Other diversions would be required to meet MPDES discharge requirements.

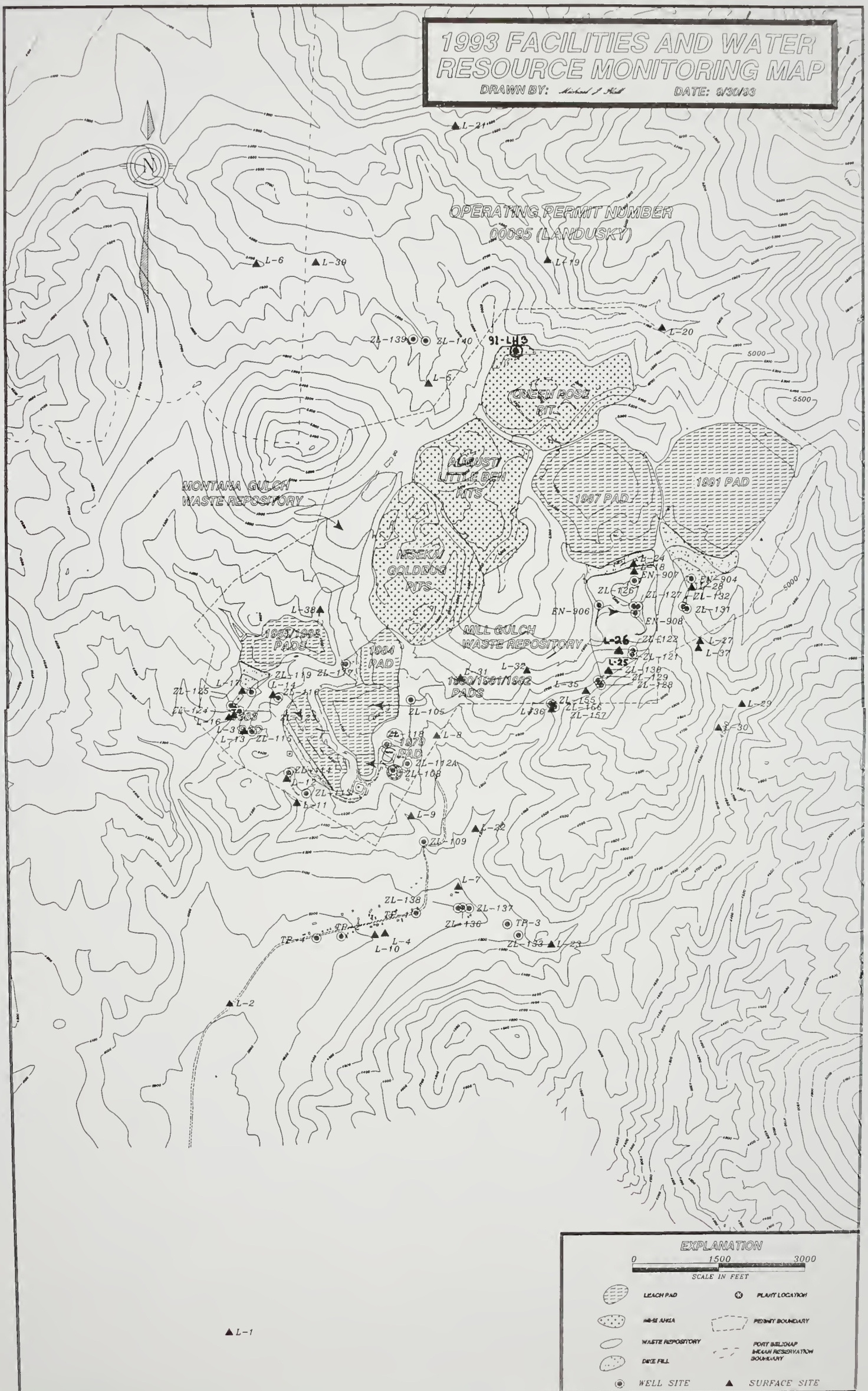
The agencies would require ZMI to place geotextile or other cushion material between the synthetic liner and the coarse rock rip rap in the diversion structures. This would be done to prevent damage to the synthetic liner.

Water Monitoring and Pumpback Systems

The agencies would require additions to the operational and general water resources monitoring plans, including installations of the following monitoring wells: one well on the west side of the Landusky processing yard (west of ZL-108 and ZL-118), a bedrock monitoring well in Montana Gulch below the '85/'86 leach pad contingency pond, and two wells (alluvial/bedrock contact and deep bedrock) at the head of King Creek, immediately below the reclaimed waste rock disposal area (Figure 10). Also, ZMI would be required to monitor 91LH-3, a 600-foot deep well located northwest of the Queen Rose pit. ZMI installed this well in 1991, but it has not been included in past monitoring plans.

In addition, frequency of general water resources monitoring would be increased from twice yearly to three times yearly by adding a sampling event in July. The agencies consider this additional monitoring necessary to aid in the evaluation of water quality trends. Raw data from ZMI's three annual sampling events would be submitted to the agencies within six weeks of each sampling event to facilitate rapid review of the data. ZMI would present quality assurance and trend analysis studies of these data sets, rather than just raw data in their annual reports.


1993 FACILITIES AND WATER RESOURCE MONITORING MAP
DRAWN BY: Michael J Kidd
DATE: 9/30/93
N
L-21
L-6
L-39
L-19
L-20
L-1
OPERATING PERMIT NUMBER
00095 (LANDUSKY)
ZL-139
ZL-140
91-LH3
5000
EXPLANATION
0
1500
3000
SCALE IN FEET
LEACH PAD
PLANT LOCATION
WASTE DUMPS
PERMIT BOUNDARY
WASTE REPOSITORY
PONY DELICHAP CREEK WATERSHED BOUNDARY
DIKE FILL
WELL SITE
SURFACE SITE


1993 FACILITIES AND WATER RESOURCE MONITORING MAP
DRAWN BY: Michael J. Hall
DATE: 9/30/93
OPERATING PERMIT NUMBER 00095 (LANDUSKY)
MONTANA GULCH WASTE REPOSITORY
QUEEN ROSE PIT
AUGUST LITTLE BEN PITS
NISEKAI GOLDBUG PITS
MILL GULCH WASTE REPOSITORY
1987 PAD
1991 PAD
1984 PAD
1979 PAD
1993/1998 PADS
1980/1981/1982 PADS
91-LH3
L-1
L-2
L-3
L-4
L-5
L-6
L-7
L-8
L-9
L-10
L-11
L-12
L-13
L-14
L-16
L-17
L-18
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L-20
L-21
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L-23
L-24
L-25
L-26
L-27
L-28
L-29
L-30
L-31
L-32
L-35
L-36
L-37
L-38
TP-3
TP-4
EXPLANATION
0
1500
3000
SCALE IN FEET
LEACH PAD
PLANT LOCATION
WASTE REPOSITORY
PERMIT BOUNDARY
DIKE FILL
WELL SITE
SURFACE SITE

The operational water resources monitoring plan would also be upgraded. Surface water monitoring site L-3 (Gold Bug adit discharge) would be monitored weekly for pH, Eh, SC, alkalinity and flow rate. Site L-5 (upper King Creek) would be sampled weekly. Sites L-19, L-20, and L-21 (South Big Horn Creek) would be sampled monthly. Currently, these sites are only sampled during the twice yearly general water resources monitoring sampling events. Access to South Big Horn Creek is extremely difficult. In order to facilitate sample collection, ZMI would be required to construct foot trails to the sampling sites. Trend analyses of these data would be submitted to the agencies four times per year. Submittal dates would coincide with the four submittals required under the general water resources monitoring plans.

The agencies under this alternative would require that operational pumpback systems be redesigned, where necessary, to handle runoff seepage resulting from a 10-year, 24-hour storm event.

C. NO ACTION ALTERNATIVE

Under the No Action Alternative ZMI would continue to monitor, mine and reclaim according to the mining and reclamation plans as approved February 28, 1991. When approved mining has been completed, operations at Landusky would cease. Any future mining would have to be addressed under a new amendment to existing permits.

D. ALTERNATIVE EVALUATED BUT DROPPED FROM CONSIDERATION

Suspension of Continued Mining

An alternative which was considered and dismissed was suspension of mining under current permits. This alternative would suspend mining operations at the Landusky mine but would allow reclamation to proceed on all existing disturbances.

Because widespread acid rock drainage problems were not predicted by the May 1990 Environmental Assessment, some citizens have suggested that the mining operation be halted. This action would not improve water quality, would result in the loss of over 200 jobs, and could potentially result in additional damage to the environment. Furthermore, a permit issued under MMRA may not be revoked unless a failure to comply with enforcement orders of the Department can be demonstrated. Similarly, enforcement may not be undertaken unless a failure to comply with permit commitments and conditions can be demonstrated. Such is not the case under MMRA. However, the MMRA provides a process for revising plans to resolve unanticipated situations. That process (82-4-337 (3)(c) MCA) has been implemented, resulting in ZMI's proposed plan changes and this environmental analysis.

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Because widespread acid rock drainage problems were not predicted by the May 1990 Environmental Assessment, some citizens have suggested that the mining operation be halted. This action would not improve water quality, would result in the loss of over 200 jobs, and could potentially result in additional damage to the environment. Furthermore, a permit issued under MMRA may not be revoked unless a failure to comply with enforcement orders of the Department can be demonstrated. Similarly, enforcement may not be undertaken unless a failure to comply with permit commitments and conditions can be demonstrated. Such is not the case under MMRA. However, the MMRA provides a process for revising plans to resolve unanticipated situations. That process (82-4-337 (3)(c) MCA) has been implemented, resulting in ZMI's proposed plan changes and this environmental analysis.

BLM regulations at 43 CFR 3809.1-7 specifically allow for already approved operations to continue subject to those corrective measures that BLM determines are needed to prevent unnecessary or undue degradation.

ZMI is currently taking actions such as partial pumpback of acidified water for use as process water, diversion of water away from potentially acid generating material, and resloping and capping of facilities constructed with acid generating material to prevent infiltration of water into these structures. It is accepted that implementation of the proposed changes or agency-modified alternatives to the reclamation plan evaluated in this EA would reduce water quality impacts over the long term. The neutral materials recovered from continued mining are the source of capping materials for reclamation. Corrective actions being implemented concurrent with mining would have more beneficial environmental effects than immediate mine closure would.

CHAPTER III - AFFECTED ENVIRONMENT

This chapter describes those portions of the environment for which changes in the impacts analysis for amendment 10 would occur. The following resources were reviewed and would not be changedby proposed modifications to the approved mining and reclamation plans: air quality, Areas of Critical Environmental Concern (ACECs), cultural resources, farmlands, floodplains, Native American religious concerns, threatened or endangered species, hazardous or solid wastes, riparian-wetlands, wild and scenic rivers, and wilderness. For more information on the affected environment and the pre-mining condition in particular, the reader is referred to MDSL 1979, 1986, 1988, and MDSL et al 1990a, 1990b and 1991.

A. GEOLOGY AND GEOCHEMISTRY

1. Existing Facilities

All Landusky Pits

All pits are active. The Gold Bug pit is no longer being mined and is being used as a waste rock dump. The Little Ben, August, and Queen Rose pits are currently being mined (Figure 2).

All Landusky Heap Leach Pads

The '79 and '80-'82 leach pads are constructed at the top of a ridge with no associated dike structure. The remainder of the pads are valley-fill type structures with existing slopes varying from 3:1 to 2:1. Prior to liner placement, a leach pad site is prepared by distributing rock fill to create a smooth foundation for the liner. Leach pad liners consist of 30 mil PVC placed over 12 inches of clay chenbonitic shale. A 12-inch layer of tailings or crushed rock, less than 1-inch diameter material, is placed over the PVC liners to protect them from puncture during ore loading. Ore heaps were constructed with run-of-mine ore in 25-foot lifts. The status and tonnage of each pad is listed below.

Pad Name	Current Tonnage	Status
'79	458,000	Reclaimed
'80-'82	3,694,000	Being rinsed
'83	2,021,000	Leaching completed, awaiting rinse
'84	3,301,000	Leaching completed, awaiting rinse
'85-'86 (MT Bulch)	5,300,000	Being leached
'87 (Mill Gulch)	38,000,000	95 percent loaded and leached
'91 (Sullivan Park)	33,900,000	68 percent loaded and leached

Since some of the waste rock associated with the Landusky deposits has proven to produce acid, releasing associated contaminants. The older leach pads would have the least potential, based on the geologic characteristics of the ore being mined at the time. It is reasonable to assume that sulfide-bearing ore may exist in all leach pads, and thus each pad has the potential to produce acid.

'85 - '86 Montana Gulch Leach Pad

ZMI was previously approved to expand this leach pad by an additional 12 million tons of ore. To date this work has not begun. Work is scheduled to begin in the spring of 1994.

'87 Mill Gulch Leach Pad

ZMI has constructed 2 process solution retention ponds on top of the '87 heap leach pad. These ponds increased the holding capacity by 56 million gallons and storage capacity increased by 12.4 percent to 452 million gallons for the entire mine complex.

Mill Gulch Waste Dump

This facility, permitted in 1988, currently contains approximately 17 million tons of waste out of a total of 35 million tons which were originally permitted to be placed. This dump was built by end dumping which has created a flat top and an angle-of-repose slope. It was intended to be used as the waste rock disposal area throughout the life of the mine.

The flow of acidic water from the toe of the dump and observed venting of sulfurous steam from portions of the dump are manifestations of the sulfide oxidation reaction occurring within the dump. ZMI has discontinued use of the Mill Gulch waste dump to decrease possible loading of contaminants to the Mill Gulch drainage. ZMI is now depositing waste in the Gold Bug pit/waste dump. This dump has little groundwater inflows associated with it because it is located at the top of a ridge.

In November 1992, ZMI decided to revise waste dump construction methods to minimize further impacts to water quality. A drain was constructed with dolomite (net neutralizing rock) between the existing contingency pond and the location of a new contingency pond which was to be constructed downstream, below the projected final "toe" of the waste rock dump. This underdrain was covered with a layer of compacted clay. Above the clay barrier, an additional drain of dolomite and limestone was placed. This design allowed unimpacted springs downgradient of the old contingency pond to flow through the lower drain and pass underneath the new contingency pond without being impacted by acidic seepage from waste rock. Seepage from the waste rock flows over the clay barrier and into the new contingency pond.

At the time of construction of this drain system, it was ZMI's intent to continue use of the Mill Gulch waste dump through the life of the mining project but to switch from end-dumping waste rock to constructing the dump in lifts. Environmental considerations later led ZMI to discontinue use of the Mill Gulch waste rock dump in favor of waste rock disposal in the Gold Bug pit.

As part of ZMI's repair and maintenance plan to reduce water infiltration and oxygen diffusion into the dump, ZMI has backsloped and capped the top of the dump with a clay cap. The top of the dump has been backsloped at 1 to 4 percent by adding at least 36 inches of non-acid generating waste (i.e. "blue" waste with less than 0.2 percent total sulfur content). A composite liner, consisting of 6 to 12 inches of clay shale has been placed over the backsloped material. Clay has also been placed over the sideslopes of the dump on the upper portion of the dump face. A 15 mil synthetic liner, used to minimize infiltration of precipitation into the dump, has been placed over all portions of the dump which have slopes less than 5 percent. The PVC liner is covered with a geofabric layer which will aid in puncture prevention. Areas which have been capped with clay and PVC have been covered with a 3-foot layer of non-acid-generating waste rock and 12 to 18 inches of soil. The majority of the wast rock dump is presently uncapped and exposed to weathering.

Gold Bug Pit/Waste Dump

The Gold Bug pit was mined by ZMI between 1979 and 1991. Possible gold resources remain within the Gold Bug deposit, but this gold cannot currently be economically mined due to a decrease in metals recovery found during metallurgical testing. A silica coating associated with hydrothermal alteration prevents cyanide from dissolving the gold. These remaining reserves are unoxidized.

The pit is oblong in shape with its long axis oriented north-south. The elevation within the pit varies from the 4650 foot level at the bottom to approximately 5325 feet at the highest point of the highwall. The pit is at the top of a ridge with a northwest facing highwall. Terraces are present on the highwall as a result of mining on 25-foot benches. Overall pitwall slope is 1:1. The pit was completed in 1991.

Waste rock produced during the on-going mining operation is being disposed of within the Gold Bug pit, where seepage can be more effectively controlled than within the Mill Gulch waste dump. In order to use the Gold Bug pit as an engineered waste rock dump, ZMI resalvaged soil material used for reclamation of the pit floor. A 3-foot thick layer of lime, limestone, and dolomite was then placed at the bottom of the pit for added neutralization. The waste dump was then constructed in 5-foot thick compacted lifts with overall 2:1 slopes, to the 4740 foot level. Waste in the dump is being segregated based upon total sulfur content, so that waste of greater than 0.5 percent total sulfur content is encapsulated within the center of the dump surrounded by waste of lower sulfur content (see Table 2).

In July 1993, the elevation of the waste material placed within the pit reached the level where the lowest pit wall daylights (elev. 4740'), and a 6-inch clay barrier was placed over the waste to prevent infiltration into the pit. This barrier is sloped at 2 percent, so that any water which infiltrates into the upper portion of the dump drain externally (Figure 11). No seeps are present on the pit walls. Most precipitation which occurs within the perimeter of the pit drains externally, due to the clay barrier, or evaporates. After completion of the clay barrier, dump construction has continued as before, with waste of higher sulfur content placed in the center, surrounded by waste of low sulfur content.

Sullivan Park ('91) Leach Pad and Contingency Pond

The Sullivan Park dike was soiled and revegetated in 1991. This structure is a benched, valley fill dam, partially constructed with acid generating rock. The dike supports the upgradient Sullivan Park leach pad. The crest is located at the 5000' level. The downslope face toes out in the valley at the 4740' level. The area under this pad may contain acid producingrock in either the underdrain system or in the exposed bedrock beneath the underdrain. At the toe of the dike, ZMI has installed a slurry cut off wall to retain acidic seepage coming from under the leach pad. Groundwater collects behind the slurry cut off wall until it reaches the surface, where it is routed to the contingency pond and is pumped back to the process circuit.

2. Regional Geology

The geology of the area (Figure 12) as well as the Landusky deposits are described in Volume 2, Appendix 2, of the Application for Amendment to Operating Permit 00096 (Zortman Mining Inc, 1992a), MDSL et al, 1990; Russell, 1991; and Knechtel, 1959.

The bedrock geology of north central Montana is dominated by a series of marine sedimentary formations with a cumulative thickness greater than one mile (Knechtel, 1959). Beneath this blanket of sediments lie metamorphic rocks, schists and gneisses, which are greater than a billion years in age. Beginning about 550 million years ago during the Paleozoic era, this area was intermittently covered by shallow inland seas in which were deposited sands and muds, and in which coral reefs developed. These sediments and reefs now make up the sandstone, shale, and limestone bedrock of the region. The deepest, oldest of these sedimentary formations is the Flathead sandstone. This unit is overlain by approximately 3,000 feet of shales, limestones, and dolomites. The upper thousand feet of this sequence is known as the Madison Group limestone, which consists of the Lodgepole and Mission Canyon formations. These were named from type sections in the Little Rocky Mountains.

EXPLANATION

BLUE WASTE REPOSITORY

4740 BARRIER LAYER
SLOPED AT 2%

DRAINAGE CHANNEL

FIGURE 11 .

0 400 800

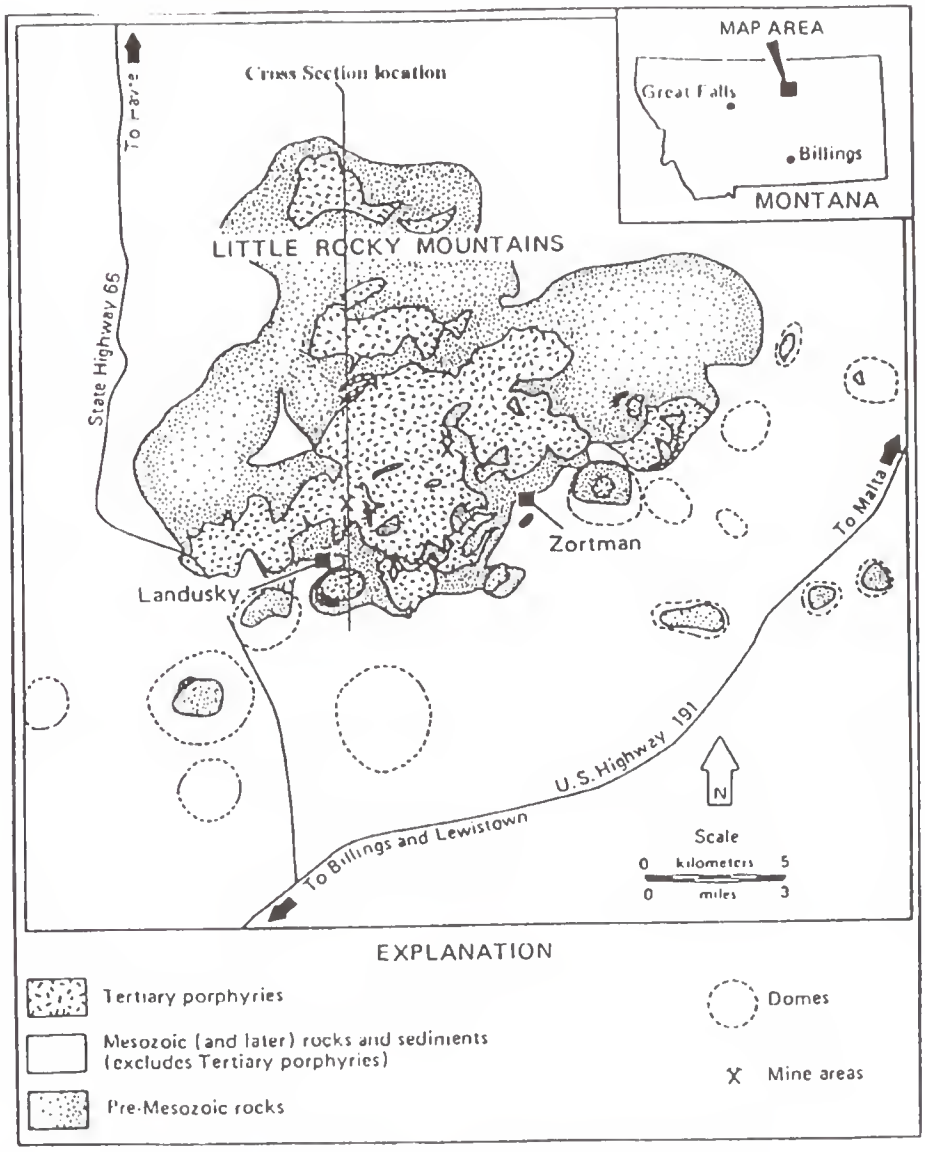
le in feet

GOLD BUG WASTE REPOSITORY
PLAN VIEW OF 474 ELEVATION

ZORTMAN MINING INC.

DRAWN BY: Michael J. Flatt 06/15/

Geologic Map of the Little Rocky Mountains (from Russell, 1991)



Shown below is an idealized cross-section of the Little Rocky Mountains.
The Location of this section is indicated on the map above.

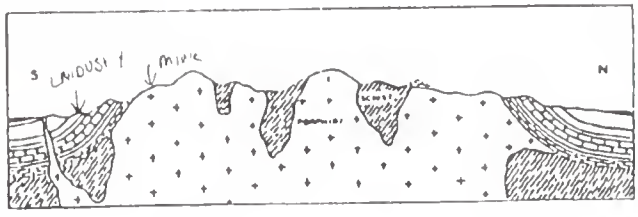


FIGURE 12.

The Jurassic age sediments which overlie the Madison Group are approximately 150 million years younger than the Mission Canyon formation. This represents a period of time when seas retreated and sediments were eroded by rivers. The Madison group limestone contains many caverns and solution cavities, which probably were formed during this period of near surface exposure. This sedimentary sequence is approximately 4,000 feet thick, and is predominantly shales, although some sandstone units are present, including the Jurassic Swift formation and the Cretaceous Kootenai, Eagle, and Judith River formations. These sediments comprise the near-surface bedrock surrounding the Little Rocky Mountains, and indeed throughout much of the Great Plains.

Approximately 60million years ago, magma moved up through the earth's crust. This magma pooled beneath the Paleozoic sediments, forcing them up into a great dome. Heat from this intrusion of igneous rock caused convection of groundwater. As these hot, hydrothermal waters flowed through fractures in the intrusion, the hydrothermal solutions leached metals and other elements from the rock. The metal-rich water migrated upward, and may have reached the surface in some places, forming hot springs. In certain regions, changes in pressure, temperature, and fluid chemistry caused gold and silver to precipitate from the hydrothermal solutions. Pyrite and other metal sulfides were also deposited in such areas. Metals and sulfides were typically deposited along fractures within the rock, because these fractures were pathways for hydrothermal fluids. Some sulfides are also disseminated throughout the rocks. The pH of the groundwater during this time of hydrothermal alteration was likely very acidic.

With time, the intrusion cooled and hydrothermal alteration and gold concentration ceased. Streams rapidly eroded away the soft clays and shales which lay over the dome formed by the intrusion. When the streams had cut down to the more competent paleozoic limestones, the rate of erosion slowed and the mountains known today as the Little Rockies began to develop. During the ice ages, glaciers may have helped to cut down through the limestones, exposing the porphyritic intrusion and associated metal deposits beneath.

3. Regional Geochemistry

The major rock types associated with the deposits have varying degrees of acid neutralizing capacity. In general, the limestones and shales have the greatest neutralizing capacity and the porphyries have the least. When the mineralized area associated with the metal deposit was brought near the surface by erosion, oxygen-bearing rain waters began to infiltrate into the mineralized rock and react with the iron sulfides: pyrite, pyrrhotite and marcasite, forming sulfuric acid and iron oxides ($2\ FeS_2 + 4\ H_2O + 7.5\ O_2 \text{----}> 4\ H_2SO_4 + Fe_2O_3$). Some of this acid would then react with other minerals in the rocks and become neutralized.

Limestone is composed of calcium carbonate which readily reacts with acid water and neutralizes it ($CaCO_3 + 2H^+ \text{----}> H_2O + CO_2 + Ca^{+2}$), forming water, carbon dioxide, and calcium. Any acid rock drainage (ARD) not neutralized within the mineralized area would travel outward through fractures in the bedrock, or flow across the land surface across calcareous soils, until it reached the limestones which surround the mountain range and would then become neutralized.

This natural ARD continued until most of the sulfide located near the earth's surface had oxidized. Sulfide material located in the centers of unfractured blocks of rock, and sulfide located deep beneath the land surface, were less accessible to oxygenated groundwater and did not react.

The upper portions of the deposits, which were mined first, were the most oxidized. Weathering had removed most of the sulfides from the rock. Blasting may have exposed some sulfide by fracturing the rock, thereby exposing unoxidized pyrite to atmospheric oxygen. This newly available pyrite began to oxidize and over a period of 5 to 10 years contributed acid to the environment.

Oxidation of sulfides was occurring during this early phase of mining. However, the majority of the waste rock produced in the early stages of mining possessed enough neutralizing capacity to overcome this acid production and therefore acid production was not manifested until the neutralizing capacity was overcome.

As deeper portions of the deposits were mined, partially oxidized rock which contained more pyrite was mined. Depending on its crystal form and surface area this sulfide can oxidize rapidly when exposed to water and air, forming more acid than can be neutralized by any buffering minerals which are contained in the rock. This reaction manifested itself as ARD in the water monitoring results. Consequently, ARD began to dominate the hydrologic systems associated with the facilities located in Mill Gulch and Sullivan Creek.

It is difficult to predict the chemical behavior of materials which occur in this subsurface sulfide-oxide transition zone as they are exposed to the atmosphere when being mined. However, ARD has been identified through water monitoring. To assure materials are properly placed, the agencies have required ZMI to implement the characterization and segregation program described in Chapter II, A.

B. HYDROLOGY

1. Surface Water

In general, surface waters in high elevation creeks in the Little Rocky Mountains begin as springs fed by shallow groundwater, which in turn is recharged by infiltration from snowmelt and precipitation events. These springs originate within the porphyritic volcanic intrusion in the core of the mountain range, and flow radially outward, crossing over the Paleozoic rock units, predominantly limestones, then flowing across the Mesozoic rock units, predominantly shales, on the plains surrounding the Little Rocky Mountains. Interaction of streams with these formations causes increases in concentrations of dissolved constituents (Feltis, 1983).

In creeks where acid rock drainage (ARD) has developed, typically, the acidity is neutralized shortly after the streams begin to flow over and through the calcareous Paleozoic sediments and soils. When the streams reach these sedimentary formations, they flow over carbonate-rich bedrock and through gravels within their drainages which have eroded from the surrounding carbonate formations. Contact with these rocks causes dissolution of carbonate and neutralization of the acidity. It is not likely that the acid will use up the neutralizing capacity of these carbonate gravels with time, because large precipitation events within the Little Rocky Mountains move the coarse gravels downstream. This brings fresh rock into the drainage and abrasion between existing gravels and cobbles during sediment transport acts to remove iron oxide coatings and expose fresh surfaces.

Surface waters affected by the proposed changes to the reclamation plan include Mill Gulch and Sullivan Creek, tributaries to Rock Creek above the town of Landusky, and Montana Gulch, a tributary to Rock Creek below Landusky (Figure 12). Flows in these creeks are extremely variable. Flow rates are controlled principally by snowmelt and precipitation events. Sullivan Creek is ephemeral. Rock Creek, Mill Gulch, and Montana Gulch typically maintain surficial flow year-round within the Landusky mine's permit boundary. Rock Creek becomes intermittent below the confluence with Mill Gulch, upgradient from the town of Landusky, but regains perennial flow downgradient from Landusky. Flows within these gulches generally range from 5 to 500 gpm, depending on the season and location of flow measurement.

From its headwaters at the toe of the Mill Gulch waste rock dump, Mill Gulch flows south for one mile before reaching the town of Landusky. Along the way it crosses approximately 500 feet of Madison limestone. Sullivan Creek flows south for approximately 2,000 feet from the '91 leach pad dike until it joins Rock Creek. Rock Creek then flows approximately 1½ miles before joining Mill Gulch just above the town of Landusky. Prior to reaching Landusky, Rock Creek

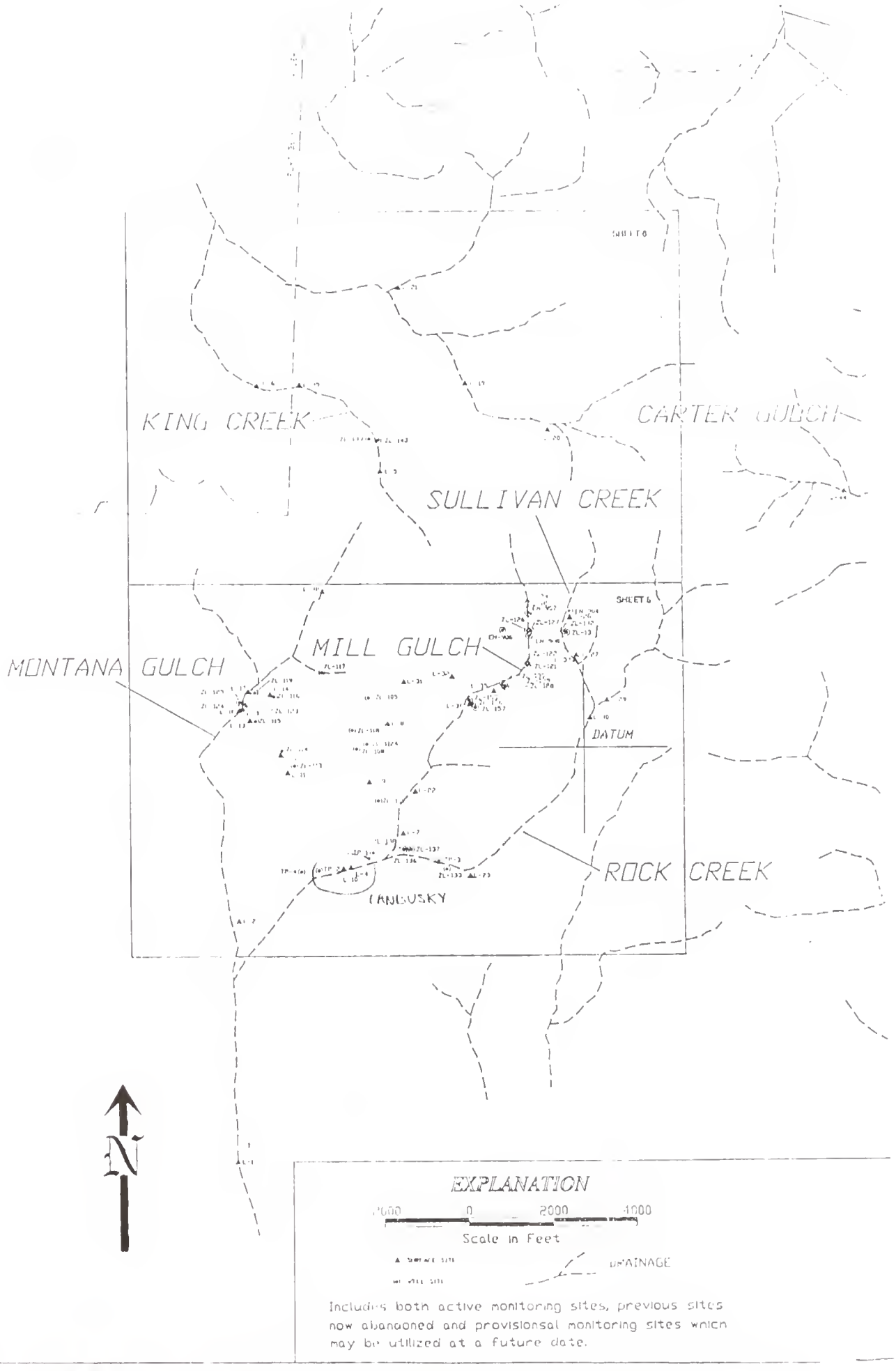


FIGURE 13. SURFACE DRAINAGE IN THE LANDUSKY AREA

crosses approximately 3,000 feet of Madison limestone outcrop. Montana Gulch flows south approximately 6,000 feet from the '85 - '86 leach pad dike and Gold Bug adit discharge point to its confluence with Rock Creek, which is approximately ½ mile downstream of the town of Landusky. Before reaching the Montana Gulch BLM campground, this surface water flows across approximately ½ mile of Madison limestone bedrock.

Surface water in upper Mill Gulch and upper Sullivan Creek has become acidic since 1991. This acidity is the result of oxidation of pyrite in waste rock placed in the Mill Gulch waste dump, the Sullivan Park dike, and possibly places within the excavated foundation of the '91 leach pad. Native materials disturbed during construction of the foundation of the Sullivan Park pad may also contain associated pyrites. As a result of this acidity, dissolved metal concentrations have risen, and Maximum Contaminant Levels (MCLs) have occasionally been exceeded for cadmium (one exceedance of cadmium MCL in upper Sullivan Creek (site L-27; 10/15/92); exceedances in upper Mill Gulch at L-26 from 5/91 through 10/92 for cadmium, and downstream at L-25 from 5/91 to 10/91). In addition, these sites have exceeded secondary MCLs for TDS, fluoride, sulfate, zinc, and pH. Water quality at site L-28 in upper Sullivan Creek is worse; however, this water from the leach pad underdrain is pumped into the contingency pond. There is no discharge to surface waters, as water collected in this pond is diverted into the processing circuit.

All Watershed Diversion Structures

Under Stipulation 11 to Amendment 010 to Operating Permit 00095, ZMI was required to provide detailed plans for watershed diversion structures. These plans are currently under review by the agencies. Diversion structures necessary for the protection of mine facilities from erosion during operations are in place. The sizing of existing diversions is under review. If data gathered during recent storm events indicates that it is necessary, these diversions will be enlarged. Also, new diversions are being constructed as reclamation proceeds.

In past amendments a storm event of 3.9 inches (100-year, 24-hour storm) was specified by ZMI for use in diversion design. The 3.9 inches came from the National Oceanic and Atmospheric Administration's (NOAA) Montana Atlas. Because the 3.9-inch event has been exceeded in 1969 and 1986 and in 1988, a reevaluation of the precipitation data and size of the 100-year, 24-hour storm was deemed necessary.

The Zortman NOAA station has a record beginning in 1966 with incomplete data in years 1983, 1986 and 1990. A Log Pearson Type III analysis was performed on 22 years of data using annual maximum, 24 hour observations. The 100-year, 24-hour storm event was found to produce approximately 6 inches of precipitation.

Because of the orographic nature of the storms in the Little Rocky Mountains, the question has been raised as to whether the rain gage in the town of Zortman, at the base of the mountains, is representative of actual rainfall amounts on top of the range where the mine site is located.

In May 1987 a Remote Automatic Weather Station (RAWS) was installed by the BLM on the ridge just east of the Carter Gulch waste rock dump at the adjacent Zortman mine to more accurately record rainfall at the mine site. To determine if there is an appreciable difference between the two stations, the 24-hour monthly maximums were plotted and an analysis of variance (ANOVA) was performed on the overlapping data (May 1987 to Dec 1989). ANOVA analysis indicates that there is no significant difference between the rainfall amounts recorded at the two stations for the same month.

During the spring and summer of 1993, the Little Rockies experienced much higher than average rainfall. Large runoff events sparked by short-duration, high-intensity thunderstorms at the mine site overwhelmed existing pumpback systems at the bottom of gulches and caused severe erosion problems. Because of these observations, peak flows for selected drainages were recalculated to see if these short-duration, high-intensity thunderstorms would produce higher peak flows than the 100-year, 24-hour event.

The most intense storm event in 1993 took place on June 28th when a thunderstorm produced 1.25 inches of rain in 1 hour. The resulting peak flow from this storm was compared to the peak flow from a 6-inch, 24-hour storm in the same drainage. The 1-hour thunderstorm produced markedly smaller peak flows than the 24-hour storm produced, indicating that the 6-inch, 24-hour storm is still a valid design parameter.

Water Monitoring and Pumpback Systems

ZMI has two water monitoring programs. Under the first, general water resources monitoring, ZMI's consultants conduct biannual sampling of all monitoring sites (Figure 13) and submit the water samples to laboratories which use EPA-approved analytical procedures. Parameters include metals, pH, cyanide, common ions, cyanide, and other indicators of water quality (Table 5). These data are submitted to the agencies annually. This monitoring program has been followed and expanded as appropriate since baseline water quality data investigations were initiated in 1977.

Table 5: Parameter List for Water Resources Monitoring, ZMI

COMPLETE ANALYSIS (C)*	
MAJOR CONSTITUENTS	
Total Suspended Solids (TSS)	Bicarbonate (HCO_3)
Total Dissolved Solids (TDS)	Carbonate (CO_3)
Turbidity (NTU)	Chloride (Cl)
Specific Electrical Conductance (SC)	Sulfate (SO_4)
pH (Field and Laboratory)	Nitrate + Nitrite as N
Flow	Total Hardness as $CaCO_3$
Depth to Water (wells only)	Total Alkalinity as $CaCO_3$
Calcium (Ca)	Acidity as $CaCO_3$(if pH less than 4.5)
Magnesium (Mg)	Ammonia (NH_3)
Sodium (Na)	Total Cyanide (CN) #
Potassium (k)	
METALS *	
Aluminum (Al)	Manganese (Mn)
Arsenic (As)	Mercury (Hg)
Cadmium (Cd)	Nickel (Ni)
Copper (Cu)	Selenium (Se)
Chromium (Cr)	Silver (Ag)
Iron (Fe)	Zinc (Zn)
Lead (Pb)	
INDICATOR ANALYSIS (I)	
pH (Field and Laboratory)	Total Hardness as $CaCO_3$
Specific Electrical Conductance (SC)	Alkalinity as $CaCO_3$
Total Dissolved Solids (TDS)	Total Cyanide (CN) #
Sulfate (SO_4)	Nitrate + Nitrite as N
OPERATIONAL ANALYSIS (I)	
pH	Specific Electrical Conductance
	Cyanide (HACH Kit)

* For groundwater, flow, total suspended solids (TSS) and turbidity will be omitted. All metals will be analyzed as dissolved in groundwater and as total recoverable in surface water. Analytical techniques to be used and laboratory detection limits are in Appendix A.

\# If total cyanide is above the laboratory detection limit, weak acid dissociable (WAD) cyanide will be tested and if either total or WAD cyanide are greater than 0.2 mg/L, then free cyanide will be tested.

ZMI's second water monitoring program, the operational water resources monitoring plan, is conducted by ZMI employees. Under this plan selected surface and ground water monitoring sites are sampled daily, weekly, or monthly depending on the importance of the site and probability of contamination, and are analyzed in ZMI's own analytical laboratory for cyanide, pH, and specific conductivity. These data are submitted to the agencies on a monthly basis, which allows for evaluation of short-term trends between receipt of the annual reports for the general water resources monitoring program. This monitoring program is also used to identify failures in containment systems, which would result in release of process solution to the environment. Agency review of monthly operational water resources monitoring reports in the summer of 1992 revealed a trend in acidification that had been developing since mid 1991 and led to the requirement that a corrective action plan be implemented. Also in the summer of 1992, ZMI review data collected under the operational monitoring plan led the company to install collection and pumpback systems to prevent release of acidified water. These pumpback systems are located in Sullivan Creek (at sites L-28 and L-27) and in Mill Gulch (site L-35) and include the recent addition of 56 million gallosn of storage capacity.

All Landusky Pits

There are no surface discharges from pits. Any water which collects in the pits infiltrates into ground waters.

All Landusky Heap Leach Pads

To date, no leach pad liners have been perforated for reclamation; therefore water within leach pads does not discharge to surface water. The existing reclamation plan allows for perforation of a leach pad liner after that leach pad has been rinsed and the cyanide solution which it contained has been neutralized. Under the current plan, puncture of the liner of any leach pad containing acid generating spent ore could result in discharge of contaminated water into the leach pad's underdrain or into groundwater beneath the leach pad. In either case, this water would enter surface water through springs or via the underdrain.

Mill Gulch Waste Dump

Materials in the Mill Gulch waste dump have generated ARD with pH of seepage from the dump dropping from 7 in 1990 to 6.5 in 1992 and periodically dropping as low as 3.9. Surface water below the waste dump but above the collection pond was sampled at site L-26 until 1993, when dump reclamation required relocation of the collection pond and burial of the old sampling site. A new sampling site has been established above the new collection pond and is designated L-

35. 1993 operational monitoring data for site L-35 indicate that the site is often dry, but may have flows of greater than 10 gpm. The pH at L-35 has varied from 4.2 to 6.8 in 1993.

Prior to 1993, Mill Gulch surface water below the collection pond was sampled at site L-25. After relocation of the pond, site L-36 was established downstream of the new pond. This site typically has flows greater than 100 gpm, and a pH in the 6.1 to 7.6 range.

Concentrations of cadmium and nitrate occasionally exceeded standards at site L-26 and L-25 these sites in 1991 and 1992, but concentrations less than one mile downstream at site L-7 did not (see Table 6 and Figure 13). In summary, impacts to these sites were localized. Further downstream outside the permit boundary, surface water at monitoring stations L-22 and L-7, located above the confluence with Rock Creek, has not shown a decrease in pH, but the concentration of sulfate has increased.

Table 6: Mill Gulch Water Quality (Sites L-25, L-26, and L-7) 1991 and 1992

		Average Concentrate		
Parameter	Standard	L-25	L-26	L-7
Arsenic	0.05 mg/L[1]	<0.005 mg/L	<0.005 mg/L	<0.005 mg/L
Cadmium	0.01 mg/L[1]	<0.018mg/L	0.385mg/L	<0.001 mg/L
Sulfate	250 mg/L[2]	502 mg/L	1620 mg/L	307 mg/L

1 - Maximum Contaminant Level (MCL) Standard
2 - Drinking Water Standard

Sullivan Park Dike/'91 Leach Pad Contingency Pond

Surface water monitoring sites within Sullivan Creek which have been impacted by acidity are designated L-28 and L-27 (Table 7). Site L-28 monitors effluent from the underdrain of the 1991 leach pad and was first sampled in May 1991, after construction began. This water discharges directly to the leach pad's contingency pond, from which it can be pumped into the processing circuit if inflow to the pond exceeds the rate of evaporation. The pH at L-28 was 3.9 in May 1991, and declined to between 2.6 and 2.8 in 1992. Over the same period, flow at L-28 declined from between 5 and 20 gallons per minute (gpm) in 1991 to 0.2 gpm in 1992. Diminished flow may be related to reclamation of the dike. Cadmium and arsenic concentrations have exceeded standards at site L-28. Site L-27 is located approximately 1/3 mile downstream of L-28.

The pH at L-27 has declined from 6.7 in 1990 to as low as 3.7 in 1992. The MCL for cadmium was exceeded in 1992 at L-27. Acidic water is currently being recovered at L-27 and used as process water. Downstream impacts, as measured at site L-23 above the confluence with Mill Gulch, appear to be negligible. During at least one storm event in July 1993, the capacity of the pumpback system at L-27 was exceeded and water bypassed this collection point. The quality of that stormwater is not known.

Table 7: Water Quality at Sites L-28, L-27, and L-23; 1991 and 1992

		Average Concentrate		
Parameter	Standard	L-28	L-27	L-23
Arsenic	0.05 mg/L[1]	2.28 mg/L	<0.005 mg/L	<0.005 mg/L
Cadmium	0.01 mg/L[1]	0.258 mg/L	0.0925 mg/L	<0.001 mg/L
Sulfate	250 mg/L[2]	2122 mg/L	1108 mg/L	120 mg/L

1 - Maximum Contaminant Level (MCL) Standard
2 - Drinking Water Standard

2. Groundwater

Alluvial Groundwater

In the affected areas, groundwater occurs in shallow alluvial deposits, within the drainages and within the underlying fractured bedrock. Observation of water quality trends at the Zortman and Landusky mines indicates that the alluvial groundwater system is strongly connected with surface water flows within these drainages. Shallow alluvial groundwater is a source of recharge to deeper, bedrock groundwater systems.

Downgradient of the mountains, shallow alluvial deposits within drainages such as Rock Creek and Little Peoples Creek provide domestic water supplies for numerous homes (Feltis, 1983). Near the Little Rocky Mountains, this groundwater is suitable for drinking water. Farther downstream, however, the alluvial groundwater becomes unpotable (Feltis, 1983). This is largely the affect of interaction of this water with the Cretaceous Judith River formation, which contains high concentrations of sodium sulfate (Feltis, 1983). The Feltis study included analyses of 14 wells on the Fort Belknap Reservation which are completed in the Judith River formation. Sulfate concentra-

tions in these wells ranged from 190 to 5,900 mg/L sulfate, with an average concentration of 1, 561 mg/L. One-half mile southwest of Hays, Feltis found concentrations of 180 mg/L sulfate in Little Peoples Creek. This concentration increased to 240 mg/L one-half mile downstream of Hays and to 380 mg/L another half-mile further downstream. This water quality change occurs as the creek crosses the Judith River formation.

Bedrock Groundwater

Bedrock formations in the study area may function as a water supply source, depending on many factors, including permeability, rock chemistry, and depth below land surface. Shales do not supply usable quantities of water due to their low yields and typically abundant salts and other soluble minerals. Volcanic igneous rocks typically transmit water through fractures within the rock. Such fractures typically do not make up a significant portion of the rock volume, so water yields are typically low. Sandstone formations may contain significant pore spaces between sand grains. For this reason, sandstone formations can hold usable volumes of groundwater and may serve as aquifers. Limestone formations can also function as aquifers, particularly if the limestone is fractured or contains abundant solution channels and caverns.

On the Fort Belknap Reservation, bedrock units which may provide groundwater suitable for drinking include the Jurassic Rierdon and Swift formations (limestone and sandstone), and the Cretaceous Kootenai and Eagle sandstone formations. The Cretaceous formations sometimes yield good quality water; however, some wells drilled into these formations contain concentrations of dissolved solids in excess of drinking water standards (Feltis, 1983). This is most likely a result of interactions of groundwater with adjacent shale formations. The Jurassic formations typically contain better quality water; however, with the exception of areas immediately adjacent to the Little Rocky Mountains, these formations are located at depths greater than 3,000 feet below land surface which makes well drilling costs prohibitive.

The Madison Group limestones lie directly beneath the Jurassic Ellis Group (Rierdon and Swift formations). The Madison Group contains significant volumes of groundwater, especially within the solution channels and caverns of the upper Mission Canyon formation. The major regional sources of recharge for the Madison aquifer are the Big Snowy, Little Belt, and Judith mountain ranges 60 to 90 miles southwest of the Little Rockies, where the Madison Group limestone outcrops over large areas (Feltis, 1983). From these mountain ranges, the Madison Group dips to the northeast. Because the land surface in the area of the Fort Belknap Reservation is mostly lower in elevation than the outcrops of Madison limestone in these distant mountain ranges, the Madison aquifer beneath the Reservation is under artesian pressure. As a result, water in wells drilled into the Madison rises to the surface, and springs such as Big and Little Warm Springs occur where the Little Rocky Mountains uplift brings the Madison Group to the land surface. Studies by Feltis

(1983) indicate that the Madison Group aquifer also receives some local recharge from the Little Rockies.

Wells drilled into the Madison Group limestones could provide dependable sources of water for irrigation on the Fort Belknap Reservation (Feltis, 1983). With the exception of areas adjacent to the Little Rocky Mountains, where the Madison limestone rises to the surface, such wells would have to be in excess of 4,000-foot depths to penetrate the Madison aquifer. This aquifer could not serve as a source for domestic or municipal drinking water supplies, however, because the water in this aquifer typically contains concentrations of total dissolved solids far in excess of drinking water standards. An exception is the community water supply well for the town of Zortman, which is completed in the Madison limestone at a depth of 738 feet. The water's relatively low total dissolved solids content, and the well's proximity to the Little Rocky Mountains and relatively shallow depth suggest that groundwater in this portion of the Madison is derived from recharge areas within the Little Rockies. In other areas within the Little Rocky Mountains, where the Madison group is near the surface, it may also be recharged by local precipitation and serve as a source for domestic water.

Water Monitoring and Pumpback Systems

Groundwater monitoring wells are sampled biannually under the general water resources monitoring plan. Monitoring well locations are shown on Figure 13, and parameters monitored for are indicated in Table 5. In addition, many monitoring wells are also sampled on a more frequent basis under the operational water quality monitoring plan. Monitoring wells located immediately downgradient of leach pads (e.g. ZL-131 and ZL-132) are also designed to function as pumpback wells which can be used to recover solution leaks. Other wells, such as 93EN904 (located between the 91 leach pad and contingency pond) have recently been installed for the purpose of recovering acidified groundwater near the source of contamination. Like effluent from the leach pad underdrain, well 93EN904 discharges into the contingency pond and is pumped back through the process circuit.

All Landusky Heap Leach Pads

All heap leach pads are underlain by composite liners are made with clay and PVC. Currently, these liners protect groundwater from process solution contained within the leach pads because no liners have been perforated to date. However, the existing reclamation plan requires for puncturing a pad's liner after the cyanide solution within that leach pad has been neutralized but prior to final reclamation. This could result in discharge of acidic solution into groundwater beneath any leach pads which contain sulfide material.

Mill Gulch Waste Dump

Shallow groundwater in upper Mill Gulch, below the waste rock dump, was monitored by wells ZL-128, ZL-129, and ZL-130 between October 1988 and October 1992. All three of these wells were completed in fractured bedrock at depths varying from 22 to 64 feet. Reclamation activities at the waste rock dump in 1993 required slope reduction, which buried these monitoring wells beneath waste rock. Samples from these wells were first analyzed for metals in March 1991. Samples from all three wells typically contained arsenic in excess of the MCL. ZL-128 sometimes also contained cadmium concentrations greater than the MCL. However, because only ZL-128 showed any water quality trends between 1988 and 1992 (increased sulfate and total dissolved solids), these metals concentrations are most likely characteristic of premining water quality. If the waste rock dump, which was started in 1988 and expanded until 1993, were the source of these metals then metal concentrations would have increased with time. These monitoring sites have been replaced by three new wells, ZL-155, ZL-156, and ZL-157, for which limited water quality data are available.

Gold Bug Pit/Waste Dump

The Gold Bug pit use to be a recharge area for the Gold Bug adit discharge. However, the pit remained dry and no inflows were observed. The quality of the adit discharge changed very little between 1977 and 1992. Only slight increases in sulfate concentration have been noted. The 1990 EA predicted that groundwater recharge from all Landusky pits averages 28 gpm. In contrast, the adit discharge averages approximately 20 times that flow. So any infiltration through the pits becomes substantially diluted by unimpacted groundwater.

Sullivan Park Dike/'91 Leach Pad Contingency Pond

Sampling of the alluvial monitoring well (ZL-132) downstream of the Sullivan Park dike indicates that sulfate concentrations in alluvial groundwater near this facility have increased. Monitoring of the bedrock monitoring well (ZL-131) indicates that impacts have remained confined to the alluvial groundwater system. In 1993, a cutoff slurry wall was installed between the 1991 leach pad dike and the contingency pond in order to collect contaminated alluvial groundwater at the surface, where it can be directed into the '91 leach pad contingency pond.

C. SOILS AND VEGETATION

Approximately 1,936,000 cubic yards of soil are stockpiled at the Landusky mine to reclaim 814 acres permitted for disturbance. Soils have been salvaged from disturbance areas and stockpiled in four stockpile areas. Eight hundred and fourteen acres are currently permitted to be reclaimed with 8 to 12 inches of soil. Approximately 764 acres have been disturbed to date, and of those over 98 acres have been reclaimed (ZMI, 1992b). Approximately 1,313,000 cubic yards are needed to reclaim 814 acres with the 12 inches of soil. ZMI has stockpiled enough soil to reclaim

814 acres with 17 to 18 inches of soil. ZMI has an approved noxious weed control program in place within the permit boundary.

Watershed Diversion Structures

Existing watershed diversion structures at the Landusky mine sustained the large flows associated with the larger storm events of 1993 and have not contributed to excessive erosion.

All Landusky Heap Leach Pads

Only 4.43 acres on the '79 leach pad have been reclaimed.

Mill Gulch Waste Dump

One area of 5.64 acres on the top of this facility has been capped with a composite clay plus PVC liner and topsoiled. Dump slopes are being reduced.

All Landusky Pits and Gold Bug Pit/Waste Dump

Pit highwalls and pit benches mined prior to the approval of Amendment 10 were not to be covered with soil during reclamation activities. As a result of the approval of Amendment 10, soils have been placed on 17.5 acres of benches in the Gold Bug pit. However, before depositing waste into the pit, these soils materials was resalvaged and stockpiled. Approximately 8 acres have been reclaimed in other pits which are still being actively mined.

Montana Gulch Waste Dump

This facility occupies an area of approximately 21 acres and has been is fully reclaimed under the currently permitted reclamation plan.

Sullivan Park Dike/'91 Leach Pad Contingency Pond

To date 30 acres of pad dikes have been reclaimed including 12.9 acres on the Sullivan Park dike. No soil has been resalvaged from this facility to date.

D. WILDLIFE AND FISHERIES

The wildlife that inhabit the western portion of the Little Rocky Mountains at the present time are: mule deer, bighorn sheep, elk, blue grouse, and various non-game species. These wildlife and their habitat are described in previous environmental documents prepared for the mine

permit and subsequent amendments. These documents, which have been mentioned previously, are incorporated by reference in this document.

The fisheries that exist are associated with downstream areas below the mountain area where the mine facilities are located (personal communication, Jim Barnum, BLM, 1993). Rock Creek below the town of Landusky contains numerous beaver dams which provide habitat for brook trout (Salvelinus fontinalis). There are no recent inventories which show the presence of brook trout in this stream at the present time. Inventories done in the late 1970s showed that the beaver dams below Landusky did contain a small population of brook trout. There have been no reports of fish kills in this area and no alteration of the stream has taken place that would cause the fish to have been impacted.

Trout fisheries in streams flowing north of the Little Rocky Mountains also have similar beaver dam habitat suitable for trout. Inventories conducted by the U.S. Fish and Wildlife Service have found brook trout populations in these streams as well.

The Montana Department of Fish, Wildlife, and Parks (MDFWP) conducted inventories on fish populations in reservoirs and perennial flowing portions of Rock Creek south of Landusky. Non-salmonid fish populations found include: flat-headed minnows, long-nose dace, white sucker, northern redbelly dace, brook stickleback, northern pike, and perch. These studies concentrated on the lower reaches of Rock Creek due to the fact that the stream often runs dry near Landusky and is not a perennial flowing stream until it is fed by springs which occur in drainages south of the mountains. Personal communication with biologists that conducted the inventory confirmed the presence of these warm water fish in Rock Creek as recent as 1990.

CHAPTER IV - ENVIRONMENTAL CONSEQUENCES

This chapter summarizes the effects of implementing the proposed corrective actions and alternatives on the resources outlined in Chapter III. Cumulative effects are described separately in the next chapter.

A. GEOLOGY AND GEOCHEMISTRY

1. ZMI Proposed Modifications

All Landusky Heap Leach Pads

No revisions to the reclamation plan have been proposed for the Landusky heap leach pads. Because some of the waste rock associated with the Landusky deposits has proven to be reactive, it may be assumed that some of the spent ore will also be reactive. Oxidation reactions would continue after final reclamation. Reclamation of these heaps without a clay barrier could allow higher infiltration rates and subsequent development of acid rock drainage and associated contaminants migration (Harries et al, 1987; Ritchie et al, 1987; and SRK et al, 1992).

Gold Bug Pit/ Waste Dump

The presence of pyrite associated with mineralization in the highwall and pit floor increases the potential for acid rock drainage to develop because of exposure to air and water. Because the pit would only be partially backfilled, a portion of the highwall would still be exposed to air and water. If portions of the highwall which remain exposed have the potential to generate acid, precipitation which runs off the highwall may become acidified and seep into the reclaimed surface. This could potentially acidify the replaced soil adjacent to the highwall which could limit vegetation along the highwall interface. Near-surface areas of the highwall have lower acid producing potential.

Dump construction has commenced by resalvaging of soil material previously placed for reclamation of the pit followed by placement of a 3-foot thick layer of lime, limestone, and dolomite at the bottom of the pit. This layer would neutralize acidic water which collects in the lower levels of the pit during construction as well as water which may seep in after reclamation. The waste dump would be built at an overall 2.25:1 slope in 5-foot thick compacted lifts to the 4,740 foot level. This would keep the permeability of the material to a minimum thereby decreasing the amount of infiltration during the life of the waste dump.

Waste in the dump is being segregated based upon total sulfur content, so that waste of greater than 0.5 percent total sulfur content would be encapsulated within the center of the dump

surrounded by waste of lower sulfur content (see Table 2). Both water and oxygen are needed for the production of acid rock drainage. This isolation of higher sulfur waste material serves to isolate it from water infiltration and atmospheric oxygen. The clay cap proposed for concurrent and final reclamation would limit the infiltration and inhibit development and migration of ARD (Harries et al, 1987; Ritchie et al, 1987; and SRK et al, 1992).

Sullivan Park Dike/'91 Heap Leach Pad Contingency Pond

Reducing the slope and installing a clay cap would decrease infiltration of precipitation and should slow oxygen transport through the facility. This would limit development and migration of acid rock drainage and its associated contaminants.

2. Agency Modified Alternative

All Landusky Heap Leach Pads and Waste Dumps

The agency modified reclamation capping scenario would inhibit the development and migration of acid rock drainage and associated metals (Harries et al, 1987; Ritchie et al, 1987; and SRK et al, 1992). Moving the Montana Gulch leach pad expansion would limit the development of ARD in Montana Gulch.

All Landusky Pit Areas

The agencies' modified reclamation plan would assure that runoff from any pit highwalls which remain exposed after backfilling is completed would not discharge from pit areas in an acidified condition.

3. No Action Alternative

All Landusky Heap Leach Pads, Pits and Waste Dumps

Facilities containing reactive rock would continue to oxidize and produce acid rock drainage.

B. HYDROLOGY

1. ZMI Proposed Modifications

a. Surface Water

Watershed Diversion Structures for Mill Gulch Waste Dump and Sullivan Park Dike:

The proposed diversion structures would carry surface runoff from these slopes, minimizing infiltration into the underlying waste rock, and would route the water around the facilities. Proposed diversions on dump and dike slopes would handle runoff from 7 inch storms. The diversion plan would also reduce soil erosion on long slopes. Infiltration of precipitation into sulfide-bearing rock would also be minimized for as long as the diversions remain functional. Failure of diversions, in the event of a storm greater than 100-year, 24-hour could result in erosion of reclaimed facilities and infiltration of stromwater into acid-generating material.

Water Monitoring and Pumpback Systems

The pumpback systems would reduce impacts to surface and ground water by collecting acidified water before it reaches surface water. The slurry cutoff wall in upper Sullivan Creek would recover acidified groundwater below the Sullivan Park dike and route it into the pumpback system. ZMI's upgraded operational water resources monitoring would provide increased verification that reclamation and solution collection and pumpback are protecting downstream water quality.

All Landusky Heap Leach Pads

Since all leach pads probably contain some acid generating material, possible consequences as a result of this proposal could be acid rock drainage from spent ore with eventual release to the environment if the leach pad liners are perforated. However, ZMI proposes to delay liner perforation until monitoring and testing assure that liner perforation would not impact surface or ground water. This would likely protect surface and groundwaters adjacent to the leach pads. However, accumulation of water within the pads could result in long-term stability problems.

Mill Gulch Waste Dump

The proposed changes to the reclamation plan would reduce the quantity of impacted surface water by reducing the amount of precipitation which infiltrates into the waste dump. This water would instead be diverted across and around this structure, and returned to the drainage below without becoming acidified. Although the quantity of seepage from these facilities would be reduced, the quality of residual seepage may not improve and could become worse. Mixing of this seepage with unimpacted seeps and with diverted runoff should dilute any residual acidity. This dilution effect would be monitored by surface water stations downgradient of the waste rock dump, such as surface water monitoring site L-36.

The quantity of surface water available to downstream users may be increased, because diversions would maintain runoff as surface water rather than allow infiltration into waste reposito-

ries and other facilities. This water would not become acidified, and therefore would be allowed to flow downstream instead of being collected and used as process water.

Gold Bug Pit/Waste Dump

The proposed backfilling and capping of the pit would reduce the amount of precipitation which infiltrates into this mineralized area. This may reduce the quantity of water which discharges from the Gold Bug adit by a minor amount.

Sullivan Park Dike/'91 Leach Pad Contingency Pond

The revised reclamation plan for this dike may reduce the volume of water which flows from the underdrain into the contingency pond by reducing the amount of precipitation which infiltrates into the dike and becomes acidified. This may also improve the quality of water downstream at surface water monitoring site L-27. The slurry cutoff wall which was recently installed below the dike should reduce the volume of acidified water which bypasses the contingency pond and may prevent acidic groundwater from reaching site L-27.

b. Groundwater

Water Monitoring and Pumpback Systems

Continued collection and pumpback of acidified water during operations below facilities would reduce the risk of groundwater degradation resulting from recharge of aquifers by acidified or contaminated surface waters. Monitoring would continue to provide feedback on pumpback system effectiveness through reclamation. Pumpback would be discontinued as monitoring indicates that reclamation has been effective.

All Landusky Heap Leach Pads

ZMI's proposal is to delay perforation of leach pad liners until it is assured that water within leach pads will meet appropriate water quality standards and prevent contamination of groundwater beneath the leach pads by material contained within the pads. Effluent from underdrains may remain acidic however if the underlying bedrock, the fill material used in leach pad site preparation, and/or the rock used for underdrain construction contains sulfides. If this were to occur, ZMI would have to continue pumpback and submit alternative plans for closure for agency review and approval.

Water Diversion Structures for Mill Gulch Waste Dump and Sullivan Park Dike

Acidified groundwater currently discharges to surface water below the Mill Gulch waste dump and the Sullivan Park dike, and also recharges the shallow alluvial aquifers within these drainages. Diversion of stormwater around these facilities and diversion of precipitation which falls on these structures to side drainages via lined ditches would reduce infiltration into the facilities, which in turn would reduce the amount of groundwater which is currently becoming acidified. The proposed actions would improve the quality of groundwater in these alluvial deposits by preventing acidification of the waters which recharge them. The watershed diversions would return diverted water to the drainage at some point downstream so a net loss would not be experienced.

Mill Gulch Waste Dump

Capping of this facility with low permeability material would reduce the volume of infiltration which enters the dump.

Sullivan Park Dike/'91 Leach Pad Contingency Pond

Installation of a slurry cutoff wall between the Sullivan Park dike and the contingency pond would reduce the volume of acidified groundwater which bypasses the contingency pond.

2. Agency Modified Alternative

a. Surface Water

All Watershed Diversion Structures

ZMI would be required to verify that all critical diversions have been sized to contain peak runoff volumes from a 7-inch, 24-hour storm event. A storm event of this size has been calculated to have an average return frequency of greater than one hundred years. The diversions would also be required to have the capacity to handle runoff from short duration, high intensity events (e.g. 2 inches in an hour) which typify summer thunderstorms. Increasing the capacity of diversion structures would reduce the risk that large storm events could damage reclaimed areas and cause the release of acid rock drainage. The increase of diversion sizes may result in minor additional disturbances.

Water Monitoring and Pumpback Systems

With the construction of slurry cutoff walls and/or other appropriate structures downgradient of all acid producing facilities and the return of contaminated water to the process

circuit, the quality of surface water in upper Mill Gulch and in Sullivan Creek would improve during continued mining operations. Flows in these drainages may be slightly reduced as a result of collection and pumpback, except during storm events when water routed through diversions discharges directly to the creeks rather than infiltrating into mine facilities or into the shallow groundwater system. Minimization of infiltration into acid-generating material would alleviate the need for pumpback facilities over time.

The increased frequency of water monitoring would provide further assurance that the proposed changes to the reclamation plan are protecting and/or restoring water quality in affected drainages. The triennial trend analyses of water quality data would assist in early detection of water quality problems and subsequent remediation.

All Landusky Heap Leach Pads

Capping of leach pads which have the potential to produce acid rock drainage would reduce or prevent infiltration of precipitation into leach pads. This would assure that storm water which runs off the leach pads after reclamation is not acidic. Monitoring would be continued as long as necessary. Once the quality of water retained in the pad is assured, the liner would be perforated.

Mill Gulch Waste Dump

Reclamation of the Mill Gulch waste dump would result in a major reduction in the amount of seepage which currently enters the dump, becomes acidified, and then flows from under the dump. The revised reclamation plan would considerably reduce the amount of seepage compared to what would result from implementation of the approved reclamation plan because of the low permeability of the compacted clay layer to be placed beneath the soil layer. The lower slopes would provide greater stability and prevent rilling or gullying from opening a path for infiltrating precipitation.

Minor acidic seeps may continue to flow from the dump but the volume of seepage would be diminished over time. Mixing of this seepage with unimpacted seeps and with diverted runoff would dilute any residual acidity.

Gold Bug Pit/Waste Dump, and Other Pits

After soil is spread over pit floors and benches, infiltration would be minimized by a combination of the clay cap's ability to shed water and the vegetative cover's ability to reduce water infiltration by evapotranspiration. Diversions constructed with neutralizing material would assure that surface runoff from exposed highwalls would not result in discharge of acid water from the pit

area. Capping of the pits may improve the quality or reduce the quantity of water which discharges from the Gold Bug adit. This could improve water quality in Montana Gulch.

Sullivan Park Dike/'91 Leach Pad Contingency Pond

Increasing the capacity of the contingency pond may facilitate final reclamation of this facility because the series of ponds could be adapted to function as a wetland treatment system.

b. Groundwater

All Watershed Diversion Structures

Construction of appropriately sized diversions would minimize the potential for failure of critical diversions during anticipated storm events. Surface water and precipitation must not infiltrate facilities containing acid generating rock to assure that such facilities do not discharge acidic water into the groundwater.

Water Monitoring and Pumpback Systems

Additional required monitoring would provide added assurance that reclamation has accomplished the goal of minimizing impacts to water quality. Pumpback would continue as proposed by ZMI until operations cease. Capping and reclamation are expected to eliminate the need for further pumpback.

All Landusky Heap Leach Pads

Moving the Montana Gulch leach pad expansion out of the drainage and up to a ridge between Mill Gulch and Sullivan Creek would eliminate the likelihood of seepage to groundwater. This would also decrease totoal surface disturbances.

At final reclamation, any residual seepage of ARD into groundwater would be diluted by the ambient groundwater system and would not affect beneficial uses. This would be verified by post-reclamation monitoring. In the unlikely event that the proposed modifications to the reclamation plan do not prevent acid rock drainage, additional measures to restore water quality would be taken as determined appropriate based on post-reclamation water quality.

Mill Gulch Waste Dump

At final reclamation any residual seepage of ARD into groundwater would be diluted by the ambient groundwater system and would not affect beneficial uses. This would be assured by post-

reclamation monitoring. In the unlikely event that the proposed modifications to the reclamation plan do not prevent acid rock drainage, additional measures to restore water quality could be developed as determined appropriate based on post-reclamation water quality.

Sullivan Park Dike/'91 Leach Pad Contingency Pond

Capping of the Sullivan Park Dike may cut off recharge to the acid generating material which is causing some of the acid rock drainage below this facility. If so, no further groundwater impacts would be anticipated, and water quality would return to pre-mining conditions. If the acid drainage has additional sources such as the material used in leach pad foundation or underdrain construction, then protection of water quality would be assured by construction of a water treatment facility such as a wetland. The necessity for such additional measures cannot be determined until the proposed changes to the reclamation plan are carried out and the results monitored.

3. No Action Alternative

a. Surface Water

Water quality would continue to be impaired in the headwaters of Sullivan Creek (Upper Rock Creek), Mill Gulch, and Montana Gulch. Thus surface and groundwater uses in the immediate area could be impacted by continued generation of acid rock drainage. Because the streams must first flow over outcrops of carbonate rock such as the Emerson formation, Madison Group, and Rierdon formation, and through stream sediments derived from these formations, the water's pH would be neutralized and most dissolved metals would precipitate prior to reaching outcrops of bedrock aquifers.

All Watershed Diversion Structures

Recent storm events indicate that not all existing diversions are adequate to handle runoff from major storm events. Failure of such diversions over the long-term could result in transport of sediment and potentially acid generating rock into drainages below Landusky mine facilities.

Water Monitoring and Pumpback Systems

The current water monitoring data documented an acid rock drainage problem at the Landusky mine. Continued monitoring under the existing plan would track the progress of acid rock drainage in the various creeks and monitoring wells near the mine, and would indicate whether the problem worsens or improves as the mine is reclaimed.

Effluent from underdrains may remain acidic however if the underlying bedrock, the fill material used in leach pad site preparation, and/or the rock used for underdrain construction contains sulfides. If this were to occur, ZMI would have to continue pumpback and submit alternative plans for closure for agency review and approval.

All Landusky Heap Leach Pads

Under the no action alternative, leach pad liners would be perforated during final reclamation, and the leach pads would be reclaimed with soil and revegetated. Any water which infiltrates through this soil could become acidified and leach metals from the spent ore before flowing into the underdrains via the perforated liners. This could contribute acid and metals to surface waters. Infiltration under this alternative would be higher than that which would occur under either the proposed plan or with the agencies' modifications. Therefore, discharge rates could be higher and/or water quality could worsen. The approved leach pad expansion in Montana Gulch would continue as permitted.

All Landusky Pits

Precipitation falling into the pits could infiltrate through potentially acid producing material. If this occurred, the potential to contribute acids and metals to groundwaters exists.

Mill Gulch Waste Dump

At this time, a small portion of the Mill Gulch waste dump top is capped with 6 to 12 inches of clay on the top and approximately 6 inches of clay on the side slopes. Non-acid generating rock has been spread over this clay cap and topsoiled. If the no action alternative is selected, this waste rock dump would still be reclaimed in a manner which would reduce but may not prevent acid rock drainage. As a result, the quality of surface water in upper Mill Gulch should improve from current conditions because less precipitation would infiltrate through the dump.

Gold Bug Pit/Waste Dump

This pit is currently being backfilled with waste rock. As final dump slopes are constructed, they are being reclaimed by covering with a layer of clay, followed by non-acid generating rock, then soil. If the no action alternative were selected, ZMI would continue to dispose of waste within this facility, and would reclaim the dump as described under the company's proposal. Possible effects to surface water include discharge of acidic water which runs off the highwalls from the pit area. Capping of the Gold Bug area may improve water quality in Montana Gulch if the reduction of infiltration into the Gold Bug pit area results in reduction of discharge from the Gold Bug adit.

Sullivan Park Dike/'91 Leach Pad Contingency Pond

The dike would remain in its current state, having a 2:1 slope covered with approximately 12 inches of soil and revegetated. The contingency pond would remain at its current 750,000 gallon capacity. Surficial acid drainage from the underdrain would continue to flow into the contingency pond, where it would evaporate or be pumped into the processing circuit.

b. Groundwater

All Watershed Diversion Structures

Previously permitted diversions would not prevent stormwater from infiltrating into facilities which contain acid generating material. If the no action alternative were selected, stormwater could infiltrate into such facilities directly through diversion channels, or as a result of overtopping of diversions. This water could become acidified before recharging local groundwater systems.

Water Monitoring and Pumpback Systems

The current water monitoring program is responsible for the identification of the acid rock drainage problem at the Landusky mine. Continued monitoring under the existing plan would track the progress of acid rock drainage in the various creeks and monitoring wells near the mine, and would indicate whether the problem worsens or improves with time and as the mine is reclaimed.

All Landusky Heap Leach Pads

Perforation of leach pad liners could result in discharge of potentially acidic, metal-laden water into groundwater beneath the leach pads.

Mill Gulch Waste Dump

The clay cap which is being spread over the Mill Gulch waste rock dump should reduce infiltration of water into the dump. Acidic water within the dump would decrease and limit recharge of groundwater beneath the dump.

Gold Bug Pit/Waste Dump

Capping and reclamation of the dump would prevent infiltration of precipitation through the floor of this pit. This would reduce the amount of water which contacts sulfide materials in bedrock beneath the pit area, which may improve groundwater quality downgradient of the pit. Under the no action alternative, all other pits would be reclaimed as previously approved, with soil spread

over pit benches and revegetated. This would not prevent infiltration from entering sulfide material beneath other pits.

Sullivan Park Dike/'91 Leach Pad Contingency Pond

If the dike were not capped with clay, any water which infiltrates into the dike could become acidified and recharge groundwater beneath the dike. This acidic water would back up behind the slurry cutoff wall above the contingency pond and overflow.

C. SOILS AND VEGETATION

1. ZMI Proposed Modifications

Water Diversion Structures for Mill Gulch Waste Dump and Sullivan Park Dike

Runoff control diversions were not previously constructed around the mine's waste dumps. Additional watershed diversions around the mine's facilities would result in less run-on and infiltration into potentially reactive material and therefore provide for less surface erosion due to rilling and less seepage draining from the toe of each facility.

All Landusky Pits and Heap Leach Pads

An additional 23 acres of disturbance would be associated with the Landusky pits. This disturbance would allow access to pit walls and benches in order to implement resloping plans.

All remaining heap leach pad facilities and the existing pits would be reclaimed as previously permitted. Acres permitted for disturbance would increase slightly by 20 acres. This acreage would be associated with construction of additional access to the pads.

Gold Bug Pit/Waste Dump

The total area of soil distribution would be increased in the Gold Bug pit area from 17.48 acres to 55.18 acres if the Gold Bug pit is backfilled to the 4900 foot elevation. Implementation of the proposed plan, soil/rock scree mosaic, would result in the spreading of soil over 60 to 70 percent of the Gold Bug waste dump area (Table 8). No reduction in soil replacement depth is necessitated by this increase in area to be reclaimed. More infiltration and soil erosion is possible with the proposed soil/rock scree capping scenario.

Mill Gulch Waste Dump

The reduced slope angles and improved diversion designs would improve the long-term stability of the reclaimed surface, as compared with the previously permitted design. The previously permitted 2:1 slopes would be stable, but the long-term potential for erosion would be greater. The clay cap would maintain its integrity more readily if placed on a more gentle slope. Because the proposed overall slope angle has been reduced to allow placement of a clay cap and construction of diversions, the capacity of the dump area has been reduced. The revised reclamation plan would deincrease the previously permitted area of disturbance because the Mill Gulch waste dump was not completed to capacity. Erosion might be increased by the use of the soil/rock scree capping scenario included in the proposed modifications.

Sullivan Park Dike/'91 Leach Pad Contingency Pond

Under the proposed revisions to the reclamation plan for the Sullivan Park dike, slopes would be reduced to less steep angles. This shape would result in a more natural appearance and reduce potential for soil erosion. Some soil would be lost during the resalvaging process, but would be salvaged ahead of slope reduction. The proposed slope reduction would increase the disturbance in the dike area. The clay cap would maintain its integrity if placed on a more gentle slope. Erosion might be increased by the use of the soil/rock scree capping scenario included in the proposed modifications.

2. Agency Modified Alternative

All Watershed Diversion Structures

The agencies require that all diversions be built to accommodate the 100-year, 24-hour precipitation event. The sizing of the 100-year, 24-hour storm has been reevaluated (see Chapter III) and has increased. Therefore the total disturbance for diversions would increase by approximately 46 acres. The 7-inch sizing exceeds the stormwater regulations and would reduce erosion and enhance reclamation success.

All Landusky Heap Leach Pads and Waste Dumps

By increasing the thickness and effectiveness of the capping sequence, erosion would be reduced, vegetation success on reclaimed facilities would be increased due to less risk for soil acidification, and less impacts to vegetation downgradient from these facilities would result. The additional slope reduction would require a slightly larger area of disturbance for reclaimed facilities. Impacts to soils would be slightly greater than the proposed action in the short term, but would result in a more stable long-term soils condition.

Gold Bug Pit/Waste Dump

Complete coverage with soil would not result in an overall thinner soil replacement depth. ZMI, currently has stockpiled sufficient volumes of soil to achieve an overall 17 to 18 inches of soil replacement. The addition of a clay layer beneath the soil would likely improve revegetative success by retaining soil moisture for a longer period after precipitation events.

Sullivan Park Dike/'91 Leach Pad Contingency Pond

ZMI would redesign the contingency pond(s). This would increase disturbances in the area. However, soils would be salvaged and borrowed construction material would be tested to assure materials are non-acid generating.

3. No Action Alternative

All Watershed Diversion Structures

Diversions built to the stormwater standards are designed for operational purposes only. Long-term soil erosion and vegetation loss on reclaimed mine facilities could occur as a result of the failure of undersized diversion structures.

All Landusky Heap Leach Pads and Waste Dumps

Under the presently permitted reclamation plan, the potential exists for soil acidification and eventual failure of revegetation on some portions of the reclaimed surfaces. As soils used for reclamation acidify, revegetated areas fail and evapotranspiration decreases. ARD seepage would continue to impact vegetation downgradient.

Sullivan Park Dike/'91 Leach Pad Contingency Pond

This facility would remain unchanged. Soils would not be lost due to resalvaging but could be acidified due to reactive material below. Vegetation success could be hindered by the acidification of soil material.

D. WILDLIFE AND FISHERIES

1., 2. ZMI and Agency Modifications

Reduced impacts to water quality resulting from the proposed changes to the reclamation plans would help to return potential habitat and assure the availability of good quality water for future beneficial uses by wildlife. The fishery in Rock Creek would not likely be contaminated by acidified waters.

3. No Action Alternative

The potential exists for ARD to migrate to perennial stream reaches. If this were to occur fisheries and habitat could be affected for short distances in each stream reach until dilution became effective.

CHAPTER V - REASONABLY FORESEEABLE ACTIVITIES AND CUMULATIVE IMPACTS

This chapter identifies those reasonably foreseeable activities which could have a cumulative affect on resources when considered with the Landusky modification proposal. Following a description of these activities, the cumulative effects are evaluated.

A. REASONABLY FORESEEABLE ACTIVITIES

The following activities have been identified which may contribute cumulative effects to resources in and adjacent to the project area.

1. Exploration

No exploration activity is currently occurring at or adjacent to either the Landusky or Zortman mines. The last proposal under review was a 10-year exploration plan that involved the construction of exploration roads and would have disturbed 128 acres. This proposal has been withdrawn by ZMI and is no longer reasonably foreseeable.

Disturbances, if exploration continued, would likely be limited to increased miles of road, which cannot be estimated at this time. Existing exploration roads continue to be reclaimed. Cumulative effects would likely be limited to changes in sedimentation rates and type of vegetative cover. Because such effects can not be estimated at this time, exploratin activities have not been further evaluated for cumulative effects. Any future exploration activites must be submitted for agencies review and analysis.

2. Mining

Landusky Mine

The potential to mine additional sulfide ore reserves at the Landusky mine, in existing pits, was investigated by ZMI between 1990 and 1992. Metallurgical testing indicated that gold contained within the remainder of the orebody associated with the Gold Bug pit could not be recovered economically. ZMI is demonstrating, by the act of backfilling the Gold Bug pit, that no new mining of this pit would take place in the future. No further mineral development has been proposed at the Landusky mine. However, additional gold reserves remain at the Landusky mine, and ZMI may propose mining of additional reserves in the future if economic conditions change. Because no quantification of future economic reserves is available or reasonably foreseeable, a projection of cumulative effects of future mining at Landusky is not possible and has not been included in the cumulative effects analysis.

Additional "oxide" ore reserves (including ores which contain sulfides, but not in quantities sufficient to reduce gold recovery below economically feasible levels) may remain at the Landusky mine. If so, such reserves may be mineable at current metals prices. ZMI has not proposed additional mining at the Landusky mine beyond the limits set by Amendment 10 in 1990. Thus, additional Landusky oxide mining has not been included in the cumulative effects analysis. Any future mining, if proposed, must be submitted to the agencies for review and analysis. Such an analysis would be distributed for public comment pursuant to MEPA and NEPA.

Expansion of the Montana Gulch leach pad was approved under Amendment 10. This activity is not scheduled to begin until the spring of 1994. As previously discussed, possible alternative to this expansion would be to place this ore on a lined area between the Sullivan Park and Mill Gulch leach pads.

Zortman Mine

Zortman Mining Inc. has identified new gold reserves at the Zortman mine which would extend the mine life by 5 to 8 years. ZMI has proposed a major mine expansion which includes leaching of 80 million tons of ore on a leach pad to be located in Goslin Gulch. This proposed amendment to the existing permit would expand the waste rock dump in Carter Gulch and the OK pit. All other Zortman pits would be expanded and deepened to accommodate mining of these reserves. The Zortman mine expansion (ZMI, 1992a) proposal is currently being evaluated by the agencies, and an environmental impact statement (EIS) is currently being written. The mine expansion would begin at the Zortman mine in a few years, after completion of the current Landusky mining operation.

None of these activities are dependent on or require approval of the proposed action presented in this EA. However, cumulative effects, where they are known to occur as a result of the Landusky corrective actions, are identified below.

B. CUMULATIVE EFFECTS

1. Geology and Geochemistry

The Zortman mine expansion proposes to disturb an additional 600 acres. This would bring the total mining disturbance in the Little Rocky Mountains to 1,870 acres.

The Zortman sulfide expansion has already identified sulfide deposits with the potential to generate ARD. Thus the expansion plan includes proposals to control and prevent ARD occurrence. The effectiveness of these plans would be evaluated in detail in the EIS now being prepared on the sulfide expansion.

2. Hydrology

The proposed changes to the Landusky mine's operating and reclamation plans would improve Rock Creek water quality by reducing the amount of water acidified by interaction with reactive material. No effects from the Zortman mine would occur to the Rock Creek drainage because there is no hydrologic connection. However, the two mines share the same water circuit. Any potential effects to the overall water balance within that circuit due to large storm events would be shared by both mine areas. To date, the circuit has effectively functioned to limit potential effects.

The production of ARD at the Zortman mine would not be affected by corrective actions at the Landusky mine. However, because the two mines share the same process solution circuit and due to the increased storage capacity provided by the two new process solution retention ponds, the Zortman mine would be able to more effectively control their water balance within the process circuit and provide for more complete recovery of acidified groundwater captured by the Zortman mine's pumpback system. A corrective action plan for the Zortman mine is now being prepared.

ARD from both the existing Zortman and Landusky operations may infiltrate to the Madison aquifer. No impacts to beneficial use can be documented to date. The potential for cumulative effects is minimized by both ZMI and the agencies alternatives. Potential for a cumulative effect is increased under the no action alternative.

3. Soils and Vegetation

Generally, impacts to soils and vegetation are proportional to the acreage disturbed and the timing of disturbance. Enhancing reclamation plans at Landusky would accelerate reclamation success. This would decrease the amount of simultaneous disturbance in the Little Rocky Mountains attributable to mining.

Adequate soil has been salvaged at Landusky to produce revegetation cover and production which would limit seepage to acceptable levels. Salvaged soil resources at Zortman are adequate to produce some level of revegetation and reduction of seepage. Additional materials are desirable to produce revegetation cover and production levels that would reduce seepage to acceptable levels.

Possible sources of materials include:

1. Excess soil after reclamation of Landusky disturbances.

2. Excess blue waste (neutral waste rock) from Landusky.

3. Miscellaneous acres left to distrub for diversion, road, or other construction at Zortman.

4. Miscellaneous non-acid generating waste rock exposures at Zortman which could be quarried and/or crushed.

5. Alluvivium or colluvivum deposits near the Zortman mining area.

6. Historic tailing deposits which could be mixed with waste rock.

Therefore as a part of the Zortman corrective actions and any furture mining, if apporved, ZMI would have to salvage additional volumes of suitable materials for reclamation. These additional suitable materials would substitute for soils lost to historic mining. As a result of seeding fertilization and mulching techniques to be applied, it is unlikely that there would be any affect on overall reclamation success.

4. Wildlife and Fisheries

Cumulative effects to fisheries would not occur because the affected streams at Landusky above Rock Creek, are ephemeral and do not support fisheries.

Cumulative effects to wildlife are likely to be limited. Although 1,055 additional acres may be removed from forage production if the Zortman expansion were to be approved, 814 acres at Landusky would be returned to production through reclamation, thus, limiting effects on wildlife. Overall, loss of timbered acreage increases edge effect and increases forage available, enhancing big game and upland game birds. The corrective actions would accelerate rate of reclamation.

CHAPTER VI - CONCLUSIONS AND RECOMMENDATIONS

ZMI's proposed changes to the Landusky mine's operating and reclamation plans do not meet the agencies' goals specified in the approved permit and environmental documents. Selection of Alternative B is recommended. The agencies believe Alternative B, the ZMI plan with additional conditions described in Chapter II and summarized below, would be the most effective plan to correct acid rock drainage problems occurring at Landusky. Acidification of soils would be prevented, and acidification of water and associated metals loading to drainages would be reduced by Alternative B, the Agency Modified Alternative. The selection of this alternative may alleviate the need for future long term remediation.

ZMI's proposal has been modified under Alternative B to incorporate additional capping, water handling and monitoring requirements. These additional requirements further reduce the existing impacts beyond the levels to be achieved under ZMI's proposed corrective action plan.

Capping

Under this preferred alternative, ZMI would be required to cap and reclaim all leach pads, waste dumps, and pits in addition to the Mill Gulch dump and Gold Bug pit.

Slopes would be reclaimed at 3:1 where practicable and capping, consisting of 36 to 84 inches of yellow, 12 inches of clay, and 36 inches of blue waste, prior to soiling would be required. In addition, ZMI would be required to use 15 nonacid generating mil synthetic liners on areas with less than 5 percent grade over the clay layer. These standards are similar to the standards required by EPA at hazardous waste sites.

Monitoring

Additional geologic characterization of pits and other facilities would be required under this alternative. Prior to initiative of reclamation, ZMI would also be required to conduct 2 years of monitoring in order to establish baseline conditions within each facility so that further monitoring results can be accurately interpretted.

Monitoring of existing reclaimed sites would also be used to determine the need for further modification of reclamation plans.

ZMI would be required to conduct additional water monitoring and trend analysis beyond what was proposed. Three new wells would be constructed and both monitoring and reporting frequencies would increase.

Engineering

Diversion facilities must be redesigned to handle appropriate storm sizing based on ZMI's site-specific data. If the measures identified above are adopted, the long-term potential for ARD problems is substantially reduced and would likely be prevented. Additional measures could still be required by the agencies if monitoring identifies such a need.

The no action alternative is not preferred because of the potential for long-term ARD-related problems under this alternative.

CHAPTER VII - CONSULTATION AND COORDINATION

A. PUBLIC INVOLVEMENT

An agency press release, regarding activities and areas of concern, was published in the Billings Gazzette on February 23, 1993. In addition, public notice of the receipt of the amendment application was published on May 29, June 5, and June 12, 1993, in the Billings Gazette; on June 2, June 9, and June 16, 1993, in the Phillips County News; and on May 39, June 6, and June 13, 1993 in the Lewistown News-Argus. Many comments were received and have been considered in the development of this document.

Public involvement with activities at the ZMI operations has been a continuing process over the years. Most recently the agencies held scoping meetings for the proposed mine expansion (ZMI, 1992a) at the adjacent Zortman operation and identified numerous issues and concerns regarding ongoing operations. Scoping meetings were held December 15, 16, and 17, 1992, in Dodson and Malta and Hays, respectively. An additional scoping meeting was held April 15 in Lodgepole. Tribal members, county residents, Red Thunder International, Mineral Policy Center, the Montana Environmental Information Center, the American Wildlands Institute and many other individuals and organizations have been represented at these meetings. To date, issues, identified by the agencies' technical staff as well as the public related to acid rock drainage, are primarily water issues and are listed in Appendix 1. Appendix 1 indicates where in the document each issue is discussed.

A public notice has been published in the Lewistown and Malta newspapers noting the availability of the EA and providing a 30-day comment period. The mailing list for all interested persons currently includes approximately 165 addressees.

This EA is a joint document prepared by the Montana Department of State Lands and the Bureau of Land Management, Lewistown District. The Montana Department of Health and Environmental Sciences, Water Quality Bureau, and EPA were consulted in preparation of this document.

B. INDIVIDUALS INVOLVED IN PREPARATION

The following individuals have contributed to the preparation of this document.

Department of State Lands:

Bob Winegar	General
Pete Strazdas	Wildlife, Range, Vegetation, Soils
Pat Driscoll	Air Quality and Climate
Pat Plantenberg	Vegetation
Rebecca Miller	Geology, Geochemistry
Jeffrey Snyder	Geotechnical and Bond Calculation
Wayne Jepson	Groundwater and Surface Water Hydrology
Joe Gurrieri	Groundwater Hydrology
Eileen T. Cremer	Word Processing

Bureau of Land Management:

Scott Haight	Geology
Jim Mitchell	Geology
Joe Frazier	Hydrology
Rich Reading	Biologist

Reviewers:

Sandi Olsen	Hard Rock Bureau Chief
Tommy Butler	Legal Counsel
Tom Reid, WQB	WQB Liaison
Jamie Connell	BLM-Malta Area Manager
B. Gene Miller	BLM-Lewistown Assistant District Manager

This document was also prepared in consultation with staff from the Montana Department of Health and Environmental Sciences, Water Quality Bureau, and the United States Environmental Protection Agency.

CHAPTER VIII - GLOSSARY

acid rock drainage	acidic effluent caused by water percolation through areas where oxidation of pyrite has occurred or is occurring. May contain metals in solution.
alkalic	ingenious rocks which contain more sodium and potassium than is common, or that type of rock, or which contain more than is necessary to form feldspar from the available silica
alteration halo	a halo of mineralization associated with most metal deposits, which sometimes contains pyrite
AQB	Air Quality Bureau, Montana Department of Health and Environmental Sciences
ARD	acid rock drainage
beneficial use	any use as defined under 85-2-105, MCA
BAT	best available technology
BLM	United States Department of the Interior, Bureau of Land Management
capping	a procedure for placing waste rock, clays, soils or other materials in a manner designed to prevent infiltration of air or water
composite liner	have more than one liner, typically a clay liner covered with a PVC liner
concentration	amount of material contained in a specified volume, or the strength of a solution (mass per unit volume)
contingency ponds	ponds intended to capture leakage, seepage or overflow prior to recycling or treatment and release
cretaceous	the span of time between 135 and 60 million years ago
degradation	increase in concentration of certain regulated substances above ambient (background) levels, and may only be allowed by the DHES based on necessary social and economic concerns

DHES	Montana Department of Health and Environmental Sciences
dike	dam or buttressing structure made of waste rock
DNRC	Montana Department of Natural Resources and Conservation
dump	engineered repository for the permanent storage of rock waste materials
EA	Environmental Assessment - an environmental document of a proposed action and its effects on the environment
EC	Electrical conductivity
Eh	reduction - axidation potential
EIS	Environmental Impact Statement - a comprehensive environmental document delineating a proposed action's effects on natural and human environment. An EIS gives an in-depth look at specific issues and cumulative effects in an area. Required by the federal National Environmental Policy Act (NEPA) and the Montana Environmental Policy Act (MEPA) when significant impacts are identified
EPA	United State Environmental Protection Agency
facilities	generic term which can apply to waste rock dumps, heap leaches, tailings impoundments, stockpiles, mill and office buildings or other man-made structures
ferric hydroxide	rust, iron oxide, fine-grained precipitate formed from the precipitation of iron from solution,
Forestry BMP's	Best Management Practices used in logging operations for protecting water quality. These guidelines include road design and construction methods and stream-side management zones for minimizing impacts to surface water.
geotextile	synthetic material that is used in construction to create desired soil properties and conditions. Geotextiles are used to increase tensile and bearing strength for equipment access, to control water management and flow direction, and are used as filters between materials of varying particle size distribution.

gpm	gallons per minute, unit of fluid flow
heap leach	a) noun: a deposit of mined ore placed on a liner to allow for controlled recovery of gold
	b) verb: dissolution of soluble metals from ore by the application of dilute cyanide solution
HRB	Hard Rock Bureau of the Montana Department of State Lands
impermeable	not permitting passage especially of fluids
infiltration	to pass into or through a substance, as in filtering
intrusion	the igneous rock formed by the process of emplacement of magma
iron disulfide	pyrite, fool's gold, or any other iron sulfide which oxidizes to produce acid rock drainage
Jurassic	the span of time between 190 and 135 million years ago
LAD	land application disposal; disposal of neutralized waste water on an area of land which serves to deplete the water of any residual metals or arsenic
liner	material placed between a heap leach, waste rock dump or tailings impoundment and the underlying surface to provide for control of solutions or seepage
magma	molten rock material, generated within the earth and capable of intrusion and extrusion
MDSL	Montana Department of State Lands
MEPA	Montana Environmental Policy Act
metamorphic rock	rocks which have been subjected to high temperatures and pressures
mg/L	milligrams per liter, unit of concentration
mil	one thousandth of an inch, about the thickness of a potatoe chip

MMRA	Montana Metal Mine Reclamation Act
MPDES	Montana Pollution Discharge Elimination System
NEPA	National Environmental Policy Act
NNP	net neutralizing potential, the capacity of the rock material to neutralize acid produced by the oxidation of pyrite
orographic precipitation	rainfall which occurs in mountainous areas
perforation	puncturing - usually proposed for liners at the end of mine life to assure the facility is free draining
permeable	that which can be passed through, as by liquids, opposite of impermeable
pH	measure of the acidity or alkalinity; 7 is neutral, low numbers are acidic
planar	flat; level
porphyry	a type of igneous rock of any composition which contains conspicuous crystals in a fine-grained groundmass or matrix
ppm	parts per million, unit of concentration
process circuit	pipes, ponds and other containment systems a mine uses to recover valuable metals; may include leach pads, pregnant ponds, barren ponds and carbon absorption plants and the solutions within these systems
pumpback system	a system of wells or ponds pumps and pipelines designed to capture surface or ground waters so that they can be pumped to another site for use or treatment
pyrite	iron disulfide; fool's gold
slurry cutoff	a low permeability barrier placed in the ground to control migration of contaminated seepage
sump	catchment pond for collection of waste water or runoff

synthetic liner	liner constructed of man-made materials - usually polyvinyl chloride (PVC) or some other type of plastic
waste rock	material which is mined but does not contain enough precious metals to be classified as ore
wetlands	"Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances, do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." (40 CFR 230.3 and 33 CFR 238.3).
WQB	Water Quality Bureau, Montana Department of Health and Environmental Sciences

CHAPTER IX - REFERENCES

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C. PERSONAL COMMUNICATION

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MDFWP Kent Gilge, Chinook Montana

Rich Reading

APPENDIX 1

The following table identifies where in this document the reader can find a discussion of the issues identified as a part of scoping and presented in Chapter I.

ISSUE	DISCUSSION
• What is the cause of acid rock drainage problems and how long will it persist	See Chapter I, Section B, and Chapter III, Geology and Geochemistry. The duration of ARD is much harder to predict than ARD itself. Among other factors, the duration is dependent upon the quantity and crystal form of iron disulfide present in the rocks as well as the manner in which the mineral was deposited or formed within the rocks. It is proposed to control ARD by limiting the amount of water which comes in contact with sulfide minerals in mined rock.
• What enforcement actions have been taken by the appropriate agencies to resolve the problem?	See Chapter I, Section D.
• What is the scope of the existing environmental situation and is it contained within the permit area?	See Chapter III, Geochemistry and Hydrology
• How have the agencies reassessed the mine waste characterization for the waste generated at the Landusky operation?	

See Chapter II, Sections A and B, Mine Products Characterization Program.

- Is there any threat to beneficial use of waters from acid rock drainage?

  See Chapter III, Section B, Hydrology.

- Are there local fisheries being affected by the acidic drainage?

  See Chapter III, Section D, Wildlife and Fisheries.

- What effect could acidic drainage have on adjacent fisheries?

  See Chapters III and IV, Sections D, Wildlife and Fisheries.

- What water monitoring is in place?

  See Chapter III, Hydrology, Water Monitoring and Pumpback Systems.

- How should water monitoring be changed to better characterize the existing environment?

  See Chapter II, Section B, Water Monitoring and Pumpback Systems.

- What additional monitoring is needed to assure that the remedies proposed are effective?

  See Chapter II, Section B, Water Monitoring and Pumpback Systems.

- How will water monitoring protect reservation lands?

See Chapter III, Hydrology, Water Monitoring; and Chapter II, Section B, Water Monitoring. to daye, no impacts to reservation waters have been identified. If review of data collected during water monitoring indicates that surface water or groundwater which drains onto the Reservation begins to be impacted, additional measures will be taken to arrest these impacts.

- Which facilities are affected by acid rock drainage problems?

See Chapter III, Geology.

- Are the heap leach pads reaching capacity due to the high rates of precipitation recently experienced at the mine site?

See Chapter III, Hydrology.

No, precipitation is not affecting leach pad capacity. However, water balance and the capacity of pumpback facilities and contingency ponds, which could potentially be affected, are discussed in Chapter III.

- What is the integrity of the liner under the heap leach facilities?

Monitoring results indicate the liner is intact and functioning as designed. Thru monitoring the agencies and ZMI have periodically identified leaks over the years which have been promptly repaired.

- Will puncturing the heap liners at closure cause the release of acid rock drainage to surface and ground waters?

See Chapters II and IV.

The agencies will not allow puncturing of the liners until monitoring data indicate water quality law would be complied with.

- Is the mine located in a high precipitation zone which could worsen the problem and lead to environmental damage off the permit area?

  See Chapter III, Hydrology, Diversions.

- Are there areas of the existing waste repositories where stability has been compromised due to an increase in their respective water balance?

  No.

- Will diversion of waters away from the facilities decrease the flow available to downstream users?

  No. Diversions allow for movement of waters around specific facilities. No change in drainage patterns would occur as a result of these diversions.

- Are the current pumpback systems functional?

  Chapter I, Section B; Chapters III and IV, Sections B, Water Monitoring and Pumpback Systems.

- Are the current pumpback systems designed to the correct size storm event?

  See Chapter III, Section B. Watershed Diversion Structures. Chapter II, Sections B and C.

- What geologic units are being analyzed for reactive constituents? What are the parameters of concern?

  See Chapter II, Sections A and B, Mine Products Characterization Program.

- What is being done to better characterize the reactivity of waste materials?

See Chapter II, Sections A and B, Mine Products Characterization Program.

- How effective is the mine waste characterization program just recently activated?

See Chapter II, Section B.

- What else could be done to better characterize mined material?

See Chapter II, Section B.

- What environmental problems are associated with the release of acid rock drainage?

See Chapters III and IV, Sections B and D.

- What future problems could also occur as a result of erroneous assumptions?

No "future problems" are known at present. However, the current condition could remain unabated.

- How can these problems be resolved?

If future problems develop, such problems would be evaluated on a case-by=case basis and specific corrective actions would be developed.

- What environmental effects could occur as changes in the reclamation plan are implemented?

The volume of ARD would be reduced. See Chapter IV.

- How do these current problems relate to historic problems identified by the Mineral Policy Center in November?

They don't. MPC et al raised administrative issues and identified concerns with cyanide handling at the mine.

- Is bonding adequate to assure that beneficial uses of waters are not endangered by problems with acid rock drainage?

  Bonds are being raised to cover costs associated with ARD prevention under the reclamation plan.

- Does a trust fund need to be established to treat water and maintain facilities need to be established?

  A trust fund is one of several types of bonding which may be appropriate.

- How can the agencies consider permitting a sulfide expansion when existing acid drainage problems cannot be controlled?

  The agencies are required to process all applications received. An application has been submitted for the Zortman sulfide expansion, which incorporates measure to control ARD, and thus it must be processed. No decision however, is imminent on this application. The expansion application must be thoroughly evaluated and that evaluation must be published for public comment prior to the agencies considering a decision.